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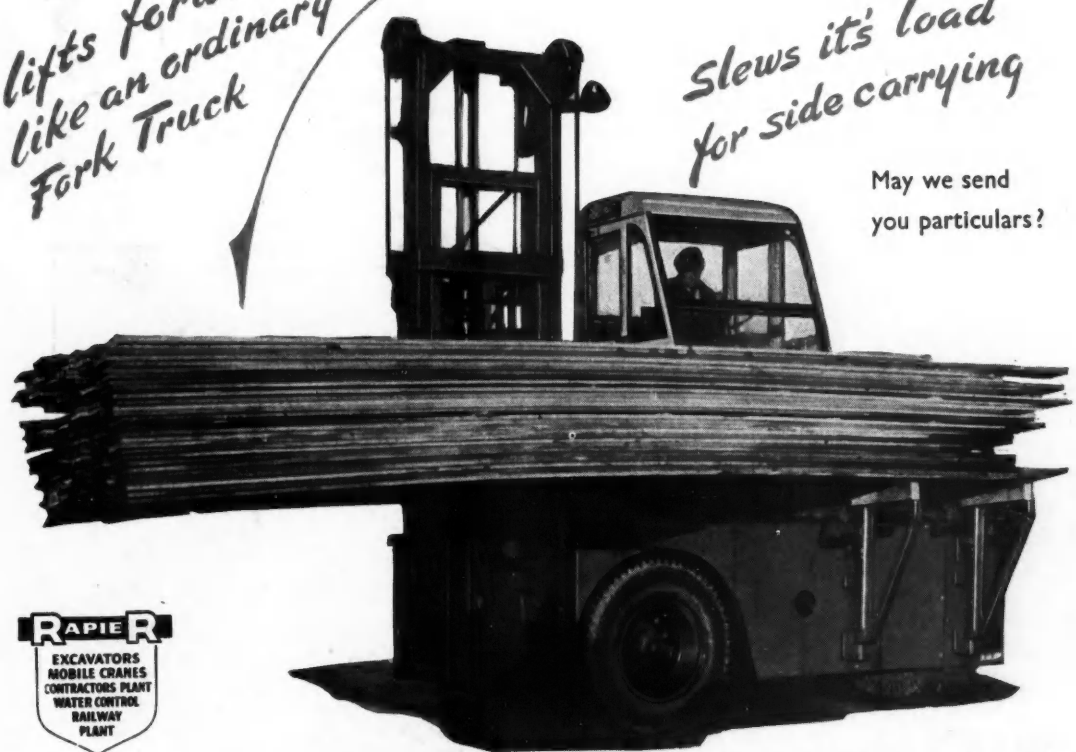

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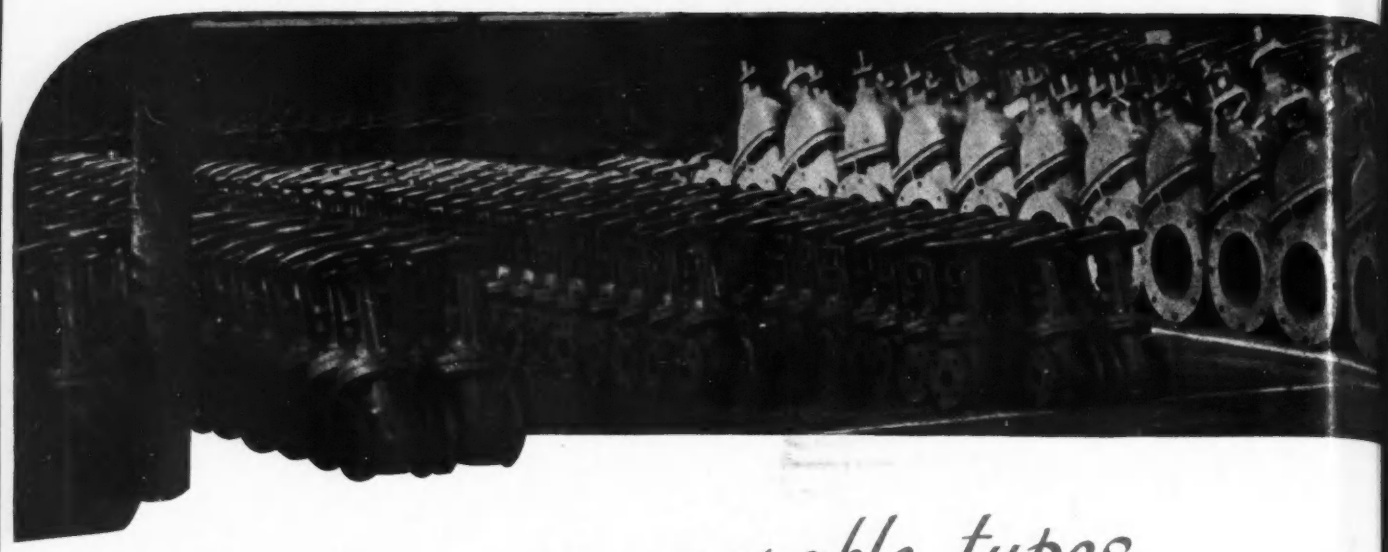

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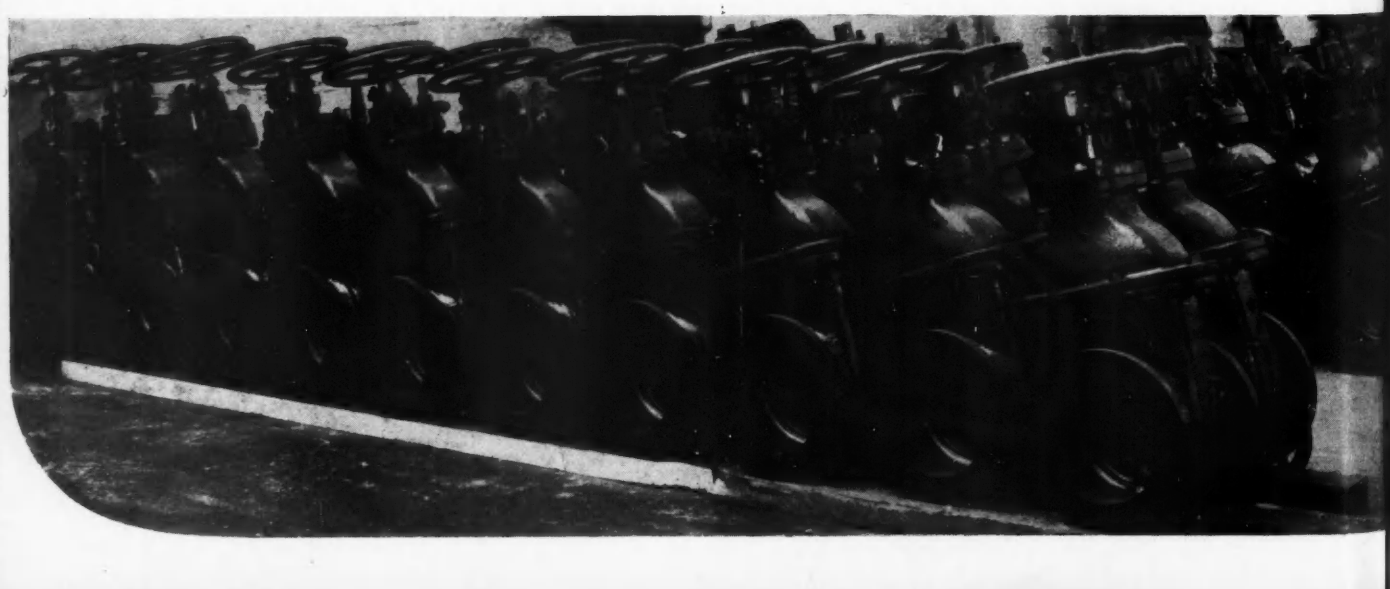


THE ENGINEER

MAY 6, 1955

Beama Annual Report

THE forty-fourth annual report of the British Electrical and Allied Manufacturers' Association (Incorporated) was presented at the annual general meeting of the Association on April 21st. It relates to the year 1954–55 and it shows that, by the end of 1954, employment in the electrical manufacturing industry stood at 670,000, or 51,400 more than in the previous year. Electrical manufacturing thus employed 7½ per cent of the labour force engaged in the country's manufacturing industries. Electrical exports from the U.K. amounted, in 1954, to £218 million (a total which was exceeded only by the record figure of £220 million in 1952) and represented one-fifth of Britain's total exports. During the year exports of generators were increased by £1,000,000 and steam turbines by £800,000; exports of electric locomotives were increased to £6,600,000, compared with £3,300,000 in 1952. A marked improvement was made in the export of domestic appliances, which increased by £6,500,000, or 22 per cent. The report shows that increasing competition was felt from West Germany, whose electrical exports were worth £141,300,000 in 1954, compared with £105,300,000 in 1953 and £89,900,000 in 1952. Europe was Germany's best customer, but South America, Asia and Africa constituted growing markets. The report also indicates that although Japan's electrical manufacturing industry made a recovery after the setback in 1953, the reports of lost orders by U.K. manufacturers by shorter delivery periods and cut prices in Japan were not so numerous as in earlier years. With regard to the activities of the Monopolies Commission the report points out that "The Beama is a non-profit making association, functioning through the voluntary co-operation of its members. By virtue of its status as an incorporated body the Beama is precluded by its articles from acting in any way that could make it a trade union. It cannot therefore engage in 'price fixing' or activities of that nature."

British Non-Ferrous Metals Research Association

AT the luncheon of the British Non-Ferrous Metals Research Association, which took place in London on May 2nd, the Minister of Supply, Mr. Reginald Maudling, spoke of the experiment in which this country was engaged to see whether a free economy could survive in the present-day world setting. An expanding export trade was necessary, he said, to maintain our financial position and to secure our imports of raw materials and of food. It was the Government's policy to remove barriers to trade and international payments, in order to achieve the greatest possible volume of trade. The policy implied that the fact of serious competition from abroad, notably from Germany and the U.S.A., must be squarely faced. Since industrialisation in those countries to which we wished to export was concentrating on simple and basic products such as cotton and raw steel, we would have to lead with products which must be of the highest quality. While we could not hope to equal the vast amount of research and development that was being expended in the U.S.A., the best service any research association could render was to help direct our efforts into the really vital sectors. Apart from other things, Mr. Maudling continued, the research associations were working out methods applicable to the whole of their respective industries; but it should be remembered that not only must our best efforts equal the best achievements abroad, but our average must also be fully up to international standards. Industry was dependent on the research associations. In reply, Dr. Maurice Cook, chairman of the Association's council, referred to the great influence which the Association had exerted since its foundation thirty-five years ago, and particularly since the establishment of its Euston Street laboratories in 1930. Dr. Cook mentioned the recent report by a committee on what might be done to strengthen further the Association's activities, and expressed the hope that shortage of technical staff would not prove an unsurmountable obstacle to such plans.

Institute of Fuel

THE report of the council of the Institute of Fuel for 1954 was published on Wednesday, April 27th, the following day being the occasion of the Institute's annual luncheon. This function was attended by a large gathering of distinguished guests, and Mr. C. M. Vignoles, who is chairman of the Petroleum Industry Advisory Council and managing director of Shell Mex and B.P., Ltd., was the principal guest. After luncheon the retiring president, Dr. W. Idris Jones, awarded the Melchett Medal to Dr. A. Parker, director of fuel research, D.S.I.R. The Students' Medal was awarded to Dr. C. M. Thomas, for his entry entitled "The Petrographic Constituents of Coal," and finally, Sir Ernest Smith, C.B.E., a past-president, was awarded his scroll signifying honorary membership of the Institute. Amongst the points made by Mr. Vignoles in his address was the growing use of oil in the world, which, he said, had increased from 24 to 51 per cent of the total energy requirements. In this country he noted that 5,000,000 to 6,000,000 tons of coal will eventually be freed by the use of 1,000,000 tons of oil on the railways, and in the steel industry an additional 1,500,000 tons of oil to that consumed in 1945 is being used. In a reference to the finances of the oil companies their vital need to expand and to undertake research, Mr. Vignoles warned that sufficient profit must be made for self-financing allowances as capital of the order it required could not be nearly obtained externally. He noted in this connection that the Royal Dutch Shell Company had allowed £800 million for this purpose. In its report the council had need to view with concern the poor results of the Institute's examinations held last May, and of the examiner's comments. It also noted that only two entries were made for the Students' Medal. The president-elect, Mr. R. H. Gummer, takes office in the autumn, and Dr. W. A. Macfarlane and Mr. W. N. C. Clinch are to serve as vice-presidents.

International Conference on Fatigue of Metals

THE council of the Institution of Mechanical Engineers has issued preliminary details of the International Conference on Fatigue of Metals, which it has arranged to take place from September 10th to September 14th this year. It is hoped to obtain up to sixty papers covering the whole field. These will be divided into groups for reading in morning and afternoon sessions, the papers in the various groups being presented for discussion in abstract form by reporters. Present knowledge of the many aspects of fatigue will be reviewed by Dr. H. J. Gough, F.R.S., in an opening address and the following two sessions will be devoted to stress effects upon the endurance of metals. Then follows single sessions on temperature and environmental effects and metallurgical aspects. The fundamental studies of the mechanism of fatigue, statistical theories, and crack propagation also have a session to themselves. The engineering and industrial significance of fatigue forms the subject of three further sessions and will be examined under the following headings: railways, automobiles, airframes, engines, pressure vessels, land and marine structures, welded construction, and an analysis of failures from fatigue phenomena. The last session will be devoted to reviews or a résumé of the problems which still appear unsolved.

Birmingham College of Technology

LAST Saturday, the diamond jubilee of the College of Technology, Birmingham, was celebrated. The ceremony included the conferment of honorary associateship of the college upon Sir Leonard Lord, Sir Frederick Handley Page, Mr. A. B. Waring, Lieut.-General Sir Ronald Weeks, and Mr. T. Williamson. In a statement, prior to the presentation of these awards, the principal of the college, Mr. J. Wilson, mentioned the dynamic state of technological education at the present time, but warned against "the danger of specialisation by well-qualified people in a comparatively narrow field of application of technological knowledge." There was a tendency, he said, to produce at its worst a perverted vision in which the life of the ant hill was mistaken for the world at large! The correctives, Mr. Wilson suggested, were wide contacts with fellow students and with people in the industrial environment, and for the student himself to be "larger than his speciality." Mr. Wilson went on to make reference to the new branches of technology which were ahead and which must be catered for in the new building to be taken over shortly by the College of Technology. Whilst, he said, the existing buildings had been planned, not without imagination, in the bicycle and steam carriage age, the new facilities must serve the new industrial age in dealing with the problems of nuclear energy, "automation," electronics, plastics, gas turbines, transistors, and many other branches of applied science which were at present in the development stage.

Opening of New Engineering Building at Sheffield University

LAST Wednesday, a new engineering building was opened by Mr. Selwyn Lloyd, Minister of Defence, at Sheffield University. A short description appears elsewhere in this issue. Before the Minister was asked to open the new building a "Congregation" was held for the Conferment of Honorary Degrees upon Mr. Selwyn Lloyd himself, Sir Richard Southwell, Professor Joseph Husband, and Mr. Ashley S. Ward. In asking Mr. Lloyd to open the new building, the Senior Pro-Chancellor, Sir Francis Stephenson, said that the building would permit the University to treble its intake of engineering students and provide for them to be taught more effectively, besides making it easier to carry on and extend many researches. The heavy structures laboratory was being named after Dr. Joseph Ward, one-time head of a great Sheffield firm, who was chairman of the Applied Science Committee for 1932 and Treasurer of the University from 1937 until his death, and the heat engines laboratory was being named after the late Professor Ripper, who came to the University in 1884, when the technical school started, became, five years later, Professor of Mechanical Engineering and Principal of the School, and from that date until his retirement in 1923 was the academic leader of all their work in applied science. In opening the new building Mr. Selwyn Lloyd remarked upon the great contribution the City had made to the defence capacity of the country. At the Ministry of Supply he had come up against the factor of the serious shortage of technologists and technicians. The tasks were to provide sufficient teachers and persuade a sufficient number of young people to take up these fields of study. The new building would fulfil an important role in national policy.

Discharge of Gas from Cylinder to Atmosphere

By R. S. BENSON, M.Sc. (Eng.), A.M.I.Mech.E., A.M.I.Mar.E.*

No. III—(*Concluded from page 584, April 29th*)

The discharge of gas from cylinder to atmosphere is analysed by the method of characteristics. It is shown that for isentropic flow a depression can occur in the cylinder under all conditions immediately at the end of the discharge, the magnitude depending on the ratio of the port area to cylinder cross-sectional area. The duration of the depression depends on the initial pressure and temperature, cylinder length and ratio of port area to cylinder cross-sectional area. Excepting in the case of certain low release pressures the magnitude of the depression is independent of the release pressure. The analysis also indicates that the mode of the discharge is different for gradual port opening compared with sudden port opening, the magnitude of the depression depending on the port area at the end of the discharge. By an approximate method the possibility of a depression occurring in two-stroke-cycle engines is examined. Curves are produced showing the port area at the end of the discharge as a function of cylinder stroke-bore ratio, port width, release pressure and temperature, cylinder length and engine speed. These curves confirm that a depression can be obtained more readily with through-scavenged engines, with a high stroke-bore ratio, earlier exhaust port opening and with a high engine number (engine speed × cylinder length).

(4) Calculation of Port Area by Approximate Method

ALTHOUGH by the use of the generalised boundary chart (Fig. 4) the computation of the pressure drop in the cylinder is rendered more easy, it is necessary to know the port area dimensions before commencing the calculation. Since in practice it is required to compute the port area, an indication of the accuracy of the approximate methods can be obtained by comparing the pressure drop by these methods with the theoretical pressure drop by the exact method. Furthermore, if a reliable method can be obtained, this could be used for computing the port area at the end of the blowdown period which, when compared with Fig. 3, will give an indication of the probable magnitude of the depression in the cylinder.

Although there are several approximate methods for computing the port area, there may be a wide variation in the calculated value, since in general the solution depends on graphical or approximate solutions of difficult integrals. This is discussed elsewhere.[1] By equating the pressure drop across the ports with the rate of mass flow neglecting the velocity in the cylinder, two differential equations can be formed.

$$-dW=\frac{A\psi}{\sqrt{RT_c}}p_c\,dt \qquad \ldots\ldots (37)$$

$$dW=\frac{1}{RT_c}\left[p_c dV_c+\frac{V_c}{\gamma}dp_c\right] \qquad \ldots (38)$$

A=effective port area.

W=weight of cylinder contents.

T_c=cylinder temperature, deg. Fah. absolute.

P_c=cylinder pressure.

R=characteristic constant.

$$\psi=\sqrt{\frac{2g\gamma}{\gamma-1}}\sqrt{\left(\frac{p_e}{p_c}\right)^{2/\gamma}-\left(\frac{p_e}{p_c}\right)^{\frac{\gamma+1}{\gamma}}}.$$

p_e=pressure in the ports.

$=p_{em}$ for subsonic flow through ports.

$=\left(\frac{2}{\gamma+1}\right)^{\frac{\gamma}{\gamma-1}}p_c$ for sonic flow through ports.

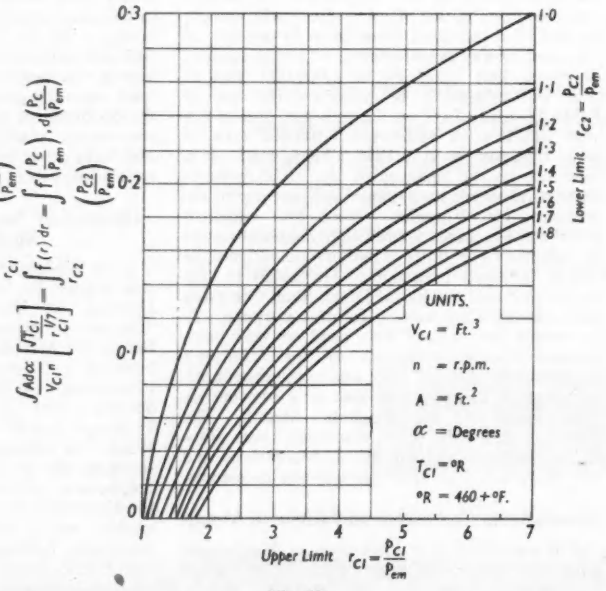


Fig. 10

Assuming constant cylinder volume V_{c1}, constant specific heat, i.e. $\gamma=1\cdot4$, and changing the variable on left-hand side to crank angle α after ports open, we have

$$\frac{\int A\,d\alpha}{nV_{c1}\left(\frac{p_{c1}}{p_{em}}\right)^{\frac{\gamma-1}{2\gamma}}}=\frac{6}{\gamma\sqrt{RT_{c1}}}\int_{r_2}^{r_1}\frac{dr}{\psi r^{\frac{3\gamma-1}{2\gamma}}} \qquad (39)$$

Suffix 1 refers to condition at commencement of port opening, suffix 2 at some arbitrary point during or at the end of the discharge period, $r=\frac{p_c}{p_{em}}$, n=r.p.m. The right-hand integral is discontinuous at the critical pressure ratio; above the critical pressure ratio $\psi=\left(\frac{2}{\gamma+1}\right)^{1/\gamma-1}\sqrt{2g\frac{\gamma}{\gamma+1}}$ and (39) can be readily solved. Below the critical ratio an exact solution can be obtained by substitution. Since in general the discharge proceeds from above critical to below critical pressure by integrating and substituting the limits r_1 and r_2, we have

$$\frac{\int A d\alpha\sqrt{T_{c1}}}{nV_{c1}\left(\frac{p_{c1}}{p_{em}}\right)^{1/7}}=0\cdot03416\Big[r_2^{2/7}(1-r_2^{-2/7})^{1/2}(2r_2^{2/7}+3)+6\cdot909\log\left(\tan\frac{\theta}{2}+\frac{\pi}{4}\right)-1\cdot1003\Big]-1\cdot0573r_1^{-1/7} \qquad \ldots\ldots (40)$$

where $\sin\theta=(1-r_2^{-2/7})$.

The right-hand side is plotted in Fig. 10 for several numerical values of r_1 and r_2, where $r_2<r_{cr}<r_1$.

Rewriting equation (40) we have

$$\frac{\int A d\alpha\,.\,\sqrt{T_{c1}}}{nV_{c1}\left(\frac{p_{c1}}{p_{em}}\right)^{1/7}}=\frac{\int\Phi d\alpha\,.\,\sqrt{T_{c1}}}{Ln\,.\left(\frac{p_{c1}}{p_{em}}\right)^{1/7}}=\int_{r_2}^{r_1}f(r)\,.\,dr=f(p) \qquad \ldots\ldots (41)$$

L=Length of cylinder, feet.

$\Phi=\frac{\text{Effective area of ports}}{\text{Cylinder cross-sectional area}}$.

The pressure time diagram for a cylinder 6in long with linear port area time characteristic and for identical conditions as the example in Fig. 6, 7, 9 calculated by this method is shown in Fig. 9. It will be seen that there is close agreement between the calculated curve by the approximate method and the exact solution, although, of course, the approximate solution cannot indicate the magnitude of the depression.

Since the magnitude of the depression depends mainly on the port area at the end of the discharge period, it is interesting to examine the factors in engine design which will be conducive to obtaining a large port area at the end of the discharge period. Since the approximate method gives good agreement at the end of the discharge, it will be assumed in this analysis that the port area when the cylinder pressure equals the exhaust pressure (p_{em}) controls the order of the magnitude of the depression. An assumption which will not be far from the truth, although, of course, the exact magnitude of the depression cannot be directly deduced from Fig. 3.

In the analysis which follows the effect of cylinder length, stroke-bore ratio, engine speed, release pressure and temperature are examined for an engine with piston-controlled ports, the effective width of which is assumed to be parallel throughout the discharge period. The following symbols are used:

$\frac{S}{D}$=stroke bore ratio.

$\frac{l}{r}$=connecting-rod crank ratio.

$K=\frac{\text{total effective port width}}{\text{circumference of cylinder}}$.

α_0=crank angle at exhaust port opening.

α=crank angle after top dead centre.

Hence

$$\Phi=4\frac{SK}{D}\cdot\frac{1}{2}\left[1-\cos\alpha+\frac{r}{2l}\sin^2\alpha\right]_{\alpha_0}^{\alpha}$$

$$=\frac{SK}{D}f(\alpha)$$

* Lecturer in Mechanical Engineering, University of Liverpool.

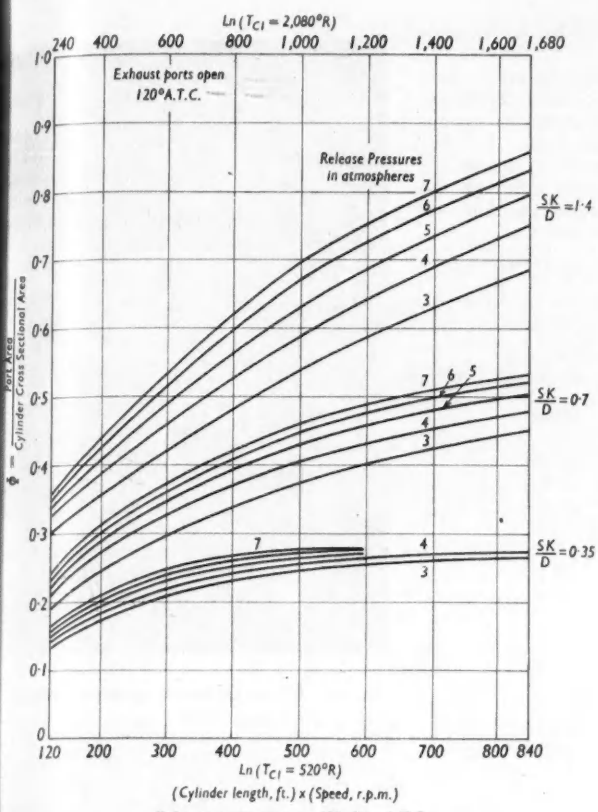

Ln (T_C1 = 2,080°R)
240 400 600 800 1,000 1,200 1,400 1,600 1,680
Exhaust ports open 120°A.T.C.
Release Pressures in atmospheres
SK/D = 1·4
SK/D = 0·7
SK/D = 0·35
Port Area / Cylinder Cross Sectional Area
Ln (T_C1 = 520°R)
120 200 300 400 500 600 700 800 840
(Cylinder length, ft.) x (Speed, r.p.m.)
Exhaust ports open at 120 deg. A.T.C.

Fig. 11—Port area ratio at end of exhaust blowdown (p_c=1 atm.) for various release pressures

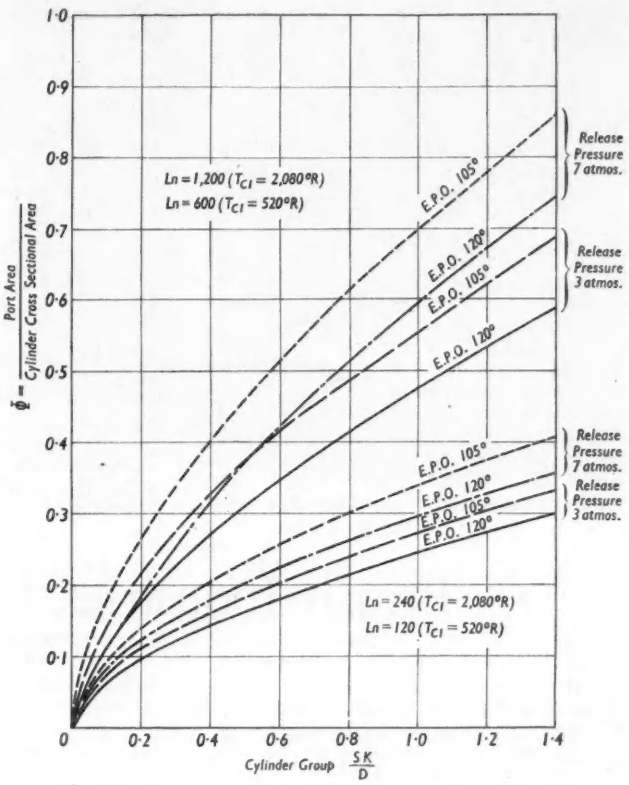

Ln = 1,200 (T_C1 = 2,080°R)
Ln = 600 (T_C1 = 520°R)
E.P.O. 105°
E.P.O. 120°
Release Pressure 7 atmos.
Release Pressure 3 atmos.
Ln = 240 (T_C1 = 2,080°R)
Ln = 120 (T_C1 = 520°R)
Port Area / Cylinder Cross Sectional Area
Cylinder Group SK/D

Fig. 12—Port area ratio at end of exhaust blowdown (p_c=1 atm.) for various release pressures, engine speeds and cylinder dimensions

$$\int_{\alpha_0}^{\alpha} \Phi \,.\, d\alpha = 4\frac{SK}{D}\int_{\alpha_0}^{\alpha}\frac{1}{2}\left(1-\cos\alpha+\frac{r}{2l}\sin^2\alpha\right)_{\alpha_0}^{\alpha}.\, d\alpha$$

$$=\frac{SK}{D}\int f(\alpha)\,.\,d\alpha\,.$$

Substituting for $\int \Phi \,.\, d\alpha$ in equation (41) we have

$$\int f(\alpha)\,.\,d\alpha=\left[\frac{D}{SK}\right]\left[\left(\frac{p_{c1}}{p_{em}}\right)^{1/7}f(p)\right]\left[\frac{Ln}{\sqrt{T_{c1}}}\right] \quad . \quad . \quad . \quad . \quad . \quad (42)$$

The left-hand side $\int f(\alpha)\,.\,d\alpha$ is a function of the kinematic mechanism, the numerical value of which, when determined, will enable $f(\alpha)$ to be obtained and, hence, the port area. The three groups which control the numerical value of $\int f(\alpha)\,.\,d\alpha$ are

(1) The cylinder dimension group,

$$\left[\frac{S}{D}K\right].$$

(2) The cylinder pressure group,

$$\left[\left(\frac{p_{c1}}{p_{em}}\right)^{1/7}f(p)\right].$$

(3) The engine speed×length group or "engine number,"

$$\left[\frac{Ln}{\sqrt{T_{c1}}}\right].$$

The numerical value of $f(\alpha)$ also depends on the crank angle at exhaust port opening (E.P.O.) α_0, the earlier the port opening the higher the value of $f(\alpha)$.

The port area ratio Φ after blowdown from several release pressures p_{c1} is plotted against "engine number" *Ln* in Fig. 11. The *l*/*r* ratio is 4, and the temperature at release T_{c1} is taken as 520 deg. Fah. absolute and 2040 deg. Fah. absolute to cover the range of values in practice, the exhaust port opening is 120 deg. A.T.D.C. Three separate cylinder dimension groups $\left[\frac{S}{D}K\right]$ have been taken corresponding to a loop scavenged cylinder with low stroke bore ratio $\left[\frac{S}{D}K=0{\cdot}35\right]$, a loop scavenged cylinder with high stroke-bore ratio or a through scavenged cylinder with low stroke-bore ratio $\left[\frac{S}{D}K=0{\cdot}7\right]$, and a through scavenged cylinder with high stroke-bore ratio $\left[\frac{S}{D}K=1{\cdot}4\right]$. The port area Φ for two representative engine numbers are replotted in Fig. 12 against $\frac{S}{D}K$ for E.P.O. 105 deg. and E.P.O. 120 deg.

Arising from these curves certain practical conclusions may be drawn.

(1) For low cylinder group numbers the port area ratio is fairly small ; in addition, the crank angle time from 120 deg. E.P.O. to obtain Φ=0·2 is 30 deg. and Φ=0·25 is 45 deg. These blowdown times are too long and in practice a smaller port area would be used ; the cylinder pressure would not drop to 1 atmosphere absolute. The chance of a depression is therefore slight.

(2) Increasing the stroke-bore ratio increases the value of Φ at the end of blowdown and hence the chance of a depression. At the same time, the blowdown period is reduced.

(3) For through scavenged engines, with ports all around the cylinder wall, the conditions are most favourable for a depression.

(4) The value of Φ is increased for early port opening and the blowdown time is reduced.

(5) Engines with high "engine numbers" (i.e. *Ln*) are more likely to have a depression than engines with low engine numbers. Since the engine number is the product of speed times cylinder length large marine engines with low speeds, 120 r.p.m., but with long cylinders 8ft to 9ft would obtain the same order of depression as high-speed engines, other conditions being equal.

(6) The effect of release pressure is about the same order as the effect of exhaust port opening. It should be mentioned that in marine practice the release pressures are of the order of 3 atmospheres absolute.

(5) Conclusions

(1) The pressure phenomena in a cylinder discharging to atmosphere can be explained by the normal fluid mechanic concepts of transient flow. In particular, the discharge process can be examined by a graphical solution of the basic equations, i.e. the method of characteristics.

(2) For sudden discharge from a cylinder the pressure drops in stages as postulated by Giffen and confirmed experimentally by Mucklow and Bannister. The magnitude of the depression at the end of the discharge is not dependent on the pressure at the commencement of the last stage except for certain initial pressures corresponding to "single" stage discharge, in which case the magnitude of the depression increases with release pressure.

The magnitude of the depression increases with increasing port area, the duration of the depression increases with cylinder pressure and cylinder length.

(3) For gradual port opening four distinct phases in the discharge process can be observed. The first two are associated with the formation of a long fronted finite wave propagated from the ports. An indicator diagram at the closed end would show a short delay period corresponding to the time for the wave front to arrive at the closed end (first phase). The second phase is associated with the reflection of the finite wave at the closed end. The third phase corresponds to the rapid fall in pressure as the ports open and the fourth phase to the depression produced by the reflection of the wave

points at the closed end. There are no pronounced periods of constant pressure as with sudden port opening, except for the first phase. The magnitude of the depression at the end of the discharge depends only on the port area at this point.

(4) By neglecting the approach velocity in the cylinder the pressure-time development in the cylinder can be calculated to give close agreement with the exact solution. By an extension of the approximate solution the factors affecting the port area ratio at the end of discharge, and, hence, the magnitude of the depression can be calculated. These calculations show that the port area at the end of discharge will be greater for through scavenged engines than loop scavenged engines, and greater for long stroke-bore ratio than for short stroke-bore ratio. The port area ratio increases with earlier port opening, release pressure and with the product of engine speed times cylinder length. The appearance of a depression in large slow-speed marine engines can therefore be satisfactorily explained.

In this analysis discharge to atmosphere has only been considered ; these conditions approximately apply for large marine engines with large-diameter exhaust pipes. For discharge into small-diameter exhaust pipe the same phenomena will occur, although the magnitude of the depression will be influenced by the ratio of pipe area to port area.

[1] "The Flow of Gases in Large Two-Stroke-Cycle Diesel Engines," Benson, R. C. J. S. Dissertation for M.Sc. (Eng.), London University, 1954.
[2] "Rapid Discharge of a Gas from Vessel into Atmosphere," Giffen, E., *Engineering*, Vol. 150 (1940), page 134.
[3] "Wave Action Following Sudden Release of Compressed Gas from a Cylinder," Bannister, F. K., and Mucklow, G. F., *Proc. I.Mech.E.*, Vol. 159 (1948), page 269.
[4] "Non-Stationary Problems of Gas Dynamics (Pressure Waves of Large Amplitude)." R. Sauer (Ministry of Supply Theoretical Research Translation 1/47).
[5] "The Application of a Graphic Method to Some Dynamic Problems in Gases," Haller, P., *Sulzer Technical Review*, 1945, No. 1, page 6.
[6] "Berechnung und Modelliversuche über Druckenwellen Grossen Amplituden in Auspuff-Leitungen," Jenny, E. (Doctors Thesis Z.T.H.S., 1949).
[7] "The Kadenacy Effect," Schweitzer, P. H., Overbake, C. W. Van, and Manson, L., *Engineering*, Vol. 160 (1945), page 241.
[8] "Sudden Discharge of Air from a Pressure Vessel," Davies S. J., *Engineering*, Vol. 149 (1940), page 17.

British Industries Fair

No. II—(*Continued from page 592, April 29th*)

THE British Industries Fair remains open at Castle Bromwich and Olympia until May 13th. Some of the engineering exhibits at Castle Bromwich are described below.

Excelsior Motor Company, Ltd.

A new truck made by the Excelsior Motor Company, Ltd., 264, King's Road, Tyseley, Birmingham, has a hydraulically elevated stillage platform which is raised by a foot-operated "Hydrum" hydraulic pump.

The steel plate platform of the truck is 5ft long by 2ft 2in wide and has an elevation of 6in. It is connected to the main chassis by four parallel links which are fitted with self-lubricating bearings. The angular movement of the hydraulic pump caused by the rise and fall of the platform is compensated for by means of flexible hose connections.

The chassis is built up from heavy gauge channel section steel and the power unit is a Villiers 1½ h.p. petrol engine with a three-speed gearbox. The steering and brakes are similar to those fitted to the standard trucks made by the firm.

Wellington Tube Works, Ltd.

In addition to the manufacture of steel tubes and fittings, Wellington Tube Works, Ltd., Tipton, Staffs, has for many years been concerned with the constructional use of steel tubes. This year the firm is showing a design of tubular pallet which is claimed has great rigidity coupled with small weight.

The company's Heaton Division is showing a "Weldex" extended surface heat exchanger. We reproduce here a photograph (Fig. 9) of this exchanger, which is built up from units of 1in o.d. tubes having 3in by 2in gills embedded in the tube walls. Depending upon the intended application, plain or stainless steel, or non-ferrous alloys may be used. The tubes are welded into headers which project through the main casing to form the external connections. In order to facilitate cleaning and maintenance, the nests of tubes can be pulled out of the casing like drawers from a chest, as may be seen from our illustration.

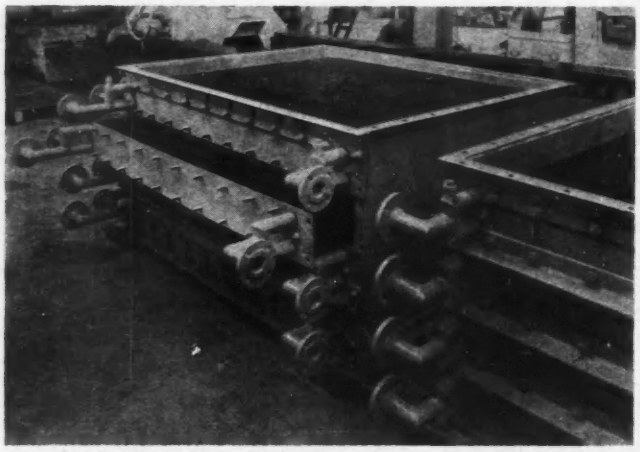


Fig. 9—Heat exchanger consisting of four nests of extended surface tubes of 1in outside diameter. The nests are removable for cleaning and maintenance—Wellington Tube

Ch. J. Neuman, Ltd.

A recent addition to the lubricating equipment made by Ch. J. Neuman, Ltd., 445, Brighton Road, South Croydon, Surrey, is the lubricator for tractors illustrated in use in Fig. 10. These lubricators can be used on all parts of a tractor or truck, topping-up gearboxes, sumps or back axles.

The equipment consists of a container with a capacity sufficient for 30 lb of lubricant and a lid with a centre section incorporating a lever-operated heavy-duty bucket pump. The pump cylinder extends down to the bottom of the container and is fitted with a non-return ball valve. Pumps of two designs can be fitted, one for delivering a large volume of self-levelling lubricant at a low pressure. The other pump is suitable for delivering lubricants or fibrous greases at a pressure of about 10,000 lb per square inch to the spout or adapter which is fitted at the end of the flexible delivery hose.

Fig. 10—Tractor lubricating equipment—Neuman

The lid of the container is held in position by three clips and it can be removed complete with the pump for the insertion of a standard 28 lb grease keg. This method of recharging the container eliminates the time wasted in emptying a keg and the attendant risk of dirt or dust being introduced with the lubricant.

Russell, Newbery and Co., Ltd.

Among the exhibits which Russell, Newbery and Co., Ltd., of Dagenham, is showing is a single-cylinder diesel-driven 400 g.p.m. pumping unit which this firm is now making (Fig. 11). By virtue of its compactness and low weight—it is stated to weigh 590 lb when fitted with radiator—it is claimed to be very suitable for irrigation purposes. The single cylinder engine has a 3¾in bore and 4½in stroke, and develops 8 h.p. at 1500 r.p.m. The cylinder head incorporates a special design of swirl chamber

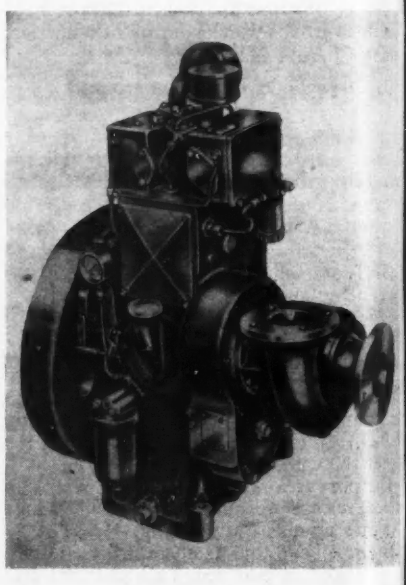


Fig. 11—"Husky" single-cylinder 8 h.p. diesel engine flange-mounted direct-coupled 400 g.p.m. pump—Russell-Newbery

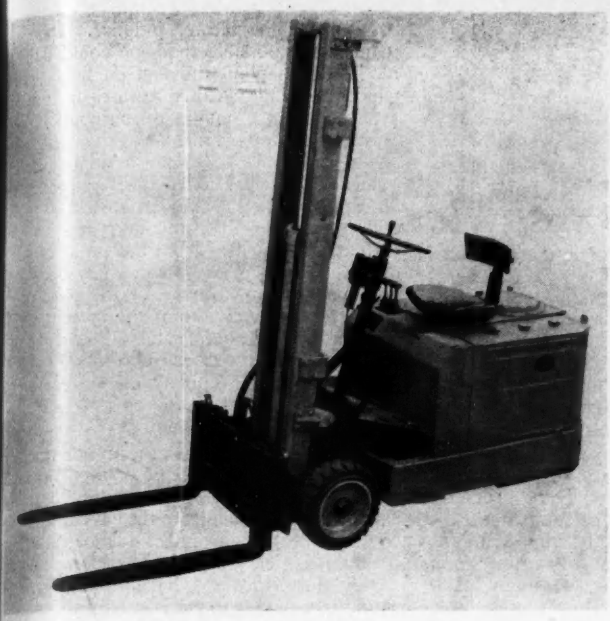


Fig. 12—2000 lb battery fork lift truck with side shift attachment to fork to facilitate eccentric lateral adjustment of the load—Conveyancer

which, it is stated, gives smooth and complete combustion without detonation. The piston is of aluminium alloy and has a floating gudgeon pin. Unified threads are used throughout in this engine, which may be tank- or radiator-cooled. The other engine which Russell, Newbery have on show is the single cylinder "RD1" model, of 4½in bore by 6in stroke, which develops 6 h.p. to 11 h.p. at 650–1250 r.p.m. (twelve-hour rating at 85 deg. Fah. ambient temperature). This engine is also supplied as a completely enclosed industrial power pack with tropical radiator and overcentre clutch.

Fisher and Ludlow, Ltd.

The mechanical conveying and handling equipment to be seen on the outdoor stand of Fisher and Ludlow, Ltd., Bordesley Works, Birmingham, 12, includes a typical arrangement for one of the firm's new "Flowmaster" systems. This overhead chain conveyor system is completely controllable by push button. The circuit shown carries eight trolley units with preselector gear. These trolley carriers can be released from parking stations and brought forward to their positions at the working points as required, and each working point is preceded by one or two storage or parking stations. Upon completion of a machine operation, the carrier with the finished component is pushed forward until it engages the conveyor chain and its position is taken up automatically by the following carrier. As the carriers on the working line move forward one station, they are automatically replaced by a succeeding trolley. As the trolley from the machine moves round the circuit it releases a further carrier from the parking stations to fill the gap in the working line.

Automatic release of carriers from the parking stations can be stopped if required, so that all carriers may be returned to their starting points, and their trolleys can be preset by push-button control to override a work station and carry on straight through the circuit.

Conveyancer Fork Trucks, Ltd.

The main exhibit of Conveyaneer Fork Trucks, Ltd., Warrington, Lancs, is the "E2–20" battery-electric fork lift truck, shown in Fig. 12. This model, a development of earlier machines, has a capacity of 2000 lb at 20in load centres. Acceleration is automatically controlled, in order to safeguard the electric gear, and three braking systems have been fitted. They comprise a hydraulically-operated foot brake and a mechanical hand brake, both of which act on the wheel brake drums, as well as a system of dynamic braking by means of controlled reverse plugging of the motor.

Yale and Towne Manufacturing Company, Inc.

Among the exhibits being shown by Yale and Towne Manufacturing Company, Inc., Wednesfield, Staffs, is showing the hydraulically operated hand-lift truck illustrated here (Fig. 13). This pallet version as well as a platform design of the truck is made to carry loads of up to 6000 lb. The welded chassis of unit construction gives good ground clearance, and thrust and radial ball bearings in the front unit facilitate steering with heavy loads. The 200 deg. swing of the handle makes the truck very manœuvrable. The heavy head casting protects the hydraulic mechanism from mechanical damage, while overloading is prevented by a preset differential relief valve. Long working life of the packing is promoted by the balanced pressure system. The oil reservoir is stated to be of ample size for long continuous service. As in previous designs, the handle is used for pumping, which, of course, need only be carried on until the load clears the ground. Right and left foot-operated controls are fitted and have positions for hoisting, neutral (handle free) and lowering. The latter is done against the oil pressure, at a speed proportional to the thrust on the pedal, thus protecting the operator as well as loads and floors. Rocker mounting of the front wheels ensures four-point contact under all road conditions. Broad steel wheels equipped with ball bearings are fitted as standard, but other kinds are available.

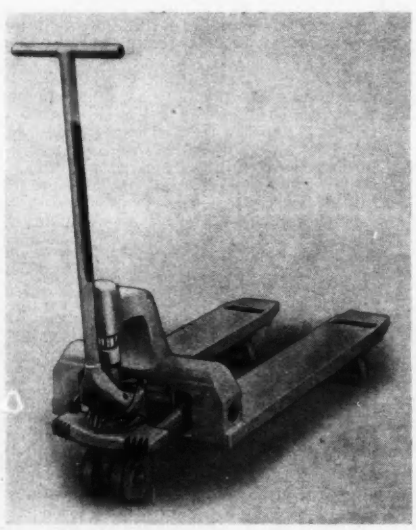


Fig. 13—Hydraulic hand-lift truck for pallet loads up to 6000 lb—Yale and Towne

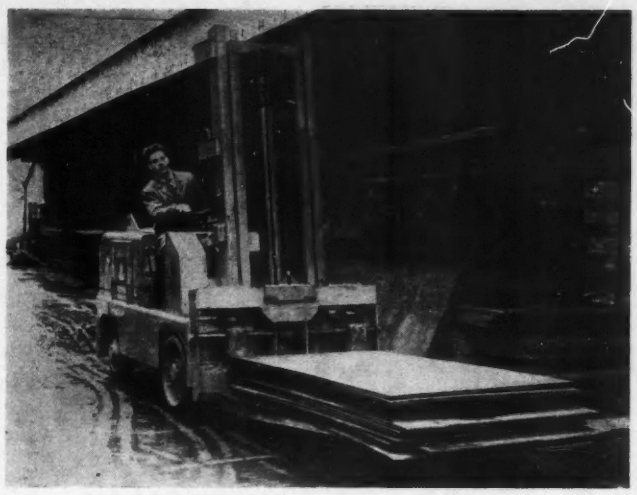


Fig. 14—12,000 lb capacity fork lift truck—Shelvoke and Drewry

Shelvoke and Drewry, Ltd.

One of the heavy duty "Freightlifter" fork lift trucks made by Shelvoke and Drewry, Ltd., of Letchworth, is the Model 72 illustrated in Fig. 14. This machine has a capacity of 12,000 lb at 24in between the face of the carriage and the centre of gravity of the load. It is particularly designed for handling heavy loads in narrow gangways down to 5ft 6in wide, and it can manœuvre in intersecting gangways only 9ft 6in wide.

The truck is similar in general design to the other heavy machines made by the firm and has diesel engine drive, power-assisted steering and brakes, and a roller mounted telescopic mast and carriage. Although primarily intended for operation on level surfaces, the truck is fitted with a self-aligning steering axle which enables such obstacles as sunken railway lines, pot-holes and uneven ground to be traversed with safety and stability.

The accessories and attachments available for use on the machine include a hydraulic side shaft, side tilt, bucket, crane jibs, boom, rotating head, &c. When fitted with the jib attachment it becomes an efficient mobile crane with a capacity of 2–4¼ tons, according to the outreach from the mast.

(*To be continued*)

Fuel Economy Booklet.—We have received from Thomas Ashworth and Co., Ltd., Vulcan Works, Burnley, a copy of a booklet which gives general details of the Ashworth system of balanced air draught. The booklet includes the reports of boiler trials carried out at various installations to support the claims made for fuel economy effected by the system which is suitable for fitting to Lancashire and horizontal shell boilers.

Iron and Steel Institute

No. I

THE eighty-sixth annual general meeting of the Iron and Steel Institute was held at 4, Grosvenor Gardens, London, S.W.1, on Wednesday and Thursday of last week, April 27th and 28th. At the opening session, on Wednesday morning, the chair was occupied by The Hon. R. G. Lyttelton, the retiring president, who voiced a welcome to the members and visitors, and particularly to the many visitors from overseas.

After the adoption of the council's annual report and the balance sheet, the following awards of medals and prizes were made :— The Bessemer Gold Medal for 1955 to Professor John Chipman, head of the Department of Metallurgy, Massachusetts Institute of Technology, in recognition of his distinguished contributions to the knowledge of the physical chemistry of steel-making ; the Sir Robert Hadfield Medal for 1955 to Mr. Tor Fjalar Holmberg, of Oy Vuoksenniska A.B., in appreciation of his meritorious service in improving the technique of the production of iron and steel at the Imatra Works, Finland ; an Andrew Carnegie Silver Medal for 1954 to Dr. B. Cine, Brown-Firth Research Laboratories, in respect of research at Sheffield University and his paper on " The Effect of Cold Work on the Gamma-Alpha Transformation in Some Fe-Ni-Cr Alloys " ; Williams Prizes for 1954, of £100 each, to Mr. W. Jackson, of Appleby-Frodingham Steel Company, for his paper on " Use of Coke-Oven Gas and Pitch-Creosote Firing on Tilting Furnaces " ; Mr. Robert McDonald, of Colvilles, Ltd., for his paper on " Steelworks Waste Heat Boiler Practice," and to Mr. A. Stirling, of Stewarts and Lloyds, Ltd., for his paper on " The Pelletising of Northampton Sand Ironstones by Vacuum Extrusion."

Following these presentations, the president announced that honorary membership of the Institute has been conferred upon Sir William Larke, an honorary vice-president, who joined the Institute in 1904, and who celebrated his eightieth birthday on April 26th. The president said he felt sure that all would agree that Sir William's achievements had been especially great in furthering co-operation in the iron and steel industry and in raising its prestige in all eyes, both at home and abroad. The president's announcement was warmly acclaimed.

Mr. Lyttelton then inducted his successor, Sir Charles Bruce-Gardner, Bt., to the presidential chair. After a vote of thanks to the retiring president, Sir Charles, who is the chairman of John Lysaght, Ltd., delivered his address, which was entitled " Our Industry : Decline and Recovery, 1910–1933." As indicated by its title, the address surveyed the course of events between the years mentioned. It was well to remember, Sir Charles commented, that the modern iron and steel industry was born in this country and that all the essential processes were technically developed by and in the industry, which enjoyed almost a world monopoly during the last century. Sir Charles ended his address with the following remarks :—

" It is difficult to say what is the value to be placed on any one factor or which relatively comes first, but there are certain essentials for the prosperity of our industry : a general condition of prosperity at home and abroad ; our home market should continue to receive such protection as is necessary to allow for the maximum use of our plants in bad times. To warrant protection we must ensure we have highly efficient plants, which compare favourably with other plants in the world, taking into account any difference in basic economic conditions, e.g. the difference in size and distribution between our home market and that of the U.S.A.; there must be a continued striving for more and more efficient fuel consumption ; the efficient use of the available raw materials ; the achievement of the highest output possible per unit of capital and per man-hour employed, and the constant improvement in the quality of our products. Obviously, all these can only be achieved by efficient management and organisation. Constant research and development will be necessary and, furthermore, it is essential that the knowledge gained should be applied at the earliest possible moment ; the time factor is all-important in this increasingly competitive age. Never let us forget that research and the application of the knowledge obtained from research is vital to prosperity in a highly competitive world. It was being first in the field with industrial products that gave us world supremacy in the export trade for almost a century. Over and above all the factors to which I have just referred, there is the overriding one of human relationship and co-operation at all levels, only achieved by leadership, both technical and personal, of the highest order."

After a vote of thanks to the president for his address, the meeting proceeded to the discussion of papers. The first was :

THE GAS-TURBO-DRIVEN BLOWER FOR BLAST-FURNACE SERVICE

By C. E. Sayer, A.M.I.C.E., A.M.I.E.E.

Synopsis

The case for the application of the gas turbine to the driving of blast-furnace blowers and the loading conditions for a single-line variable-speed gas-turbo-blower set are re-examined. The inclusion of integral blast heating with such a plant and its effects on the turbine cycle and the overall efficiency of blowing and blast heating are presented afresh with a method of graphical representation and a plea for separation of combustion air compressor and blower, instead of any form of " tapped " cycle. The suggested cycle and basic controls are described and illustrated and the paper concludes with sections dealing particularly with overall thermal efficiency, including Sankey diagrams for conventional steam plant with Cowper stoves and gas-turbine plant with and without integral blast heating, and finally with partial-load operating conditions.

Discussion

Mr. W. F. Cartwright (Steel Company of Wales, Ltd.) : I should like to emphasise that I feel that the paper has come at a very opportune moment, because much blast-furnace plant must be designed over the next few years, and I feel sure that sooner or later somebody will build a blast-furnace plant fitted with a gas-turbine blower and heat exchanger or some form of getting the heat into the blast. The difficulty appears to be that nobody is willing to take the plunge. They study this cycle and that cycle, and then they always take a look at the heat exchanger and hope that somebody else will try one first. I should like to ask the author what made him choose the temperature which he shows in the diagram. Was this the temperature which he felt was a maximum at which he could safely buy a heat exchanger to-day which would give reliability ? For it seems to me that, in comparing the conventional steam turbine axial blower, which is now becoming accepted, and stoves, one must compare the best steam practice with the best gas-turbine blower practice. It seems to me quite possible that one could build a modern steel plant on a green field site in which very high steam pressures were used, generating in a couple of big boilers and perhaps in topping turbines exhausting into gas-turbines with very high thermal efficiency —higher than mentioned in the paper. We all know that the modern stove is very efficient and reliable, and everybody would certainly be satisfied from the point of view of the working of the plant. The operator, therefore, has got to have a fairly good prize to tempt him away from this present satisfactory state of affairs, and the prize seems to be mainly in the direction of saving water, which is a bugbear of many inland steel works and even of works on the coast where they have a fresh-water problem.

I should also like to ask the author whether he has considered the possibility, if high top pressure blowing becomes adopted to any extent, whether the inlet to the gas compressor could come off the clean side of a higher pressure gas cleaning plant, and would the energy thus recovered be appreciable ? It would save having to put it into an alternator, which is the normal method which people are considering doing, so I think it might increase efficiency. If our blast-furnace practice, particularly on foreign ore, continues to improve and we get British Thermal Unit values down to 85 or 90 and higher pressures, say between 20 and 25 (at Fontana, one of the world's best thermal plants, they run somewhere between 23 and 27), and high blast heat of 1250, will these sorts of conditions improve the prospect of the gas-turbine cycle, or do they improve the relative position of the steam cycle ?

Mr. F. Kennedy (Dorman, Long (Steel), Ltd.) : There is another fundamental point which must be borne in mind in these comparisons between the gas-turbine and the steam set. The major objective is the saving of heat units and higher efficiency in the utilisation of blast-furnace gas. This is a complicated problem which is really related to the distribution of the blast-furnace gas—that the demands and the rate of production for gas do not coincide. There must be some unit which acts as a buffer to take these fluctuations, and I think most practical operators are well convinced in their own minds that the ideal user to have as a buffer is the boiler plant. You can design your boiler plant so that you get very little fall-off in efficiency if you switch over to alternative fuels ; and this question of possible alternative fuels does come very much into the comparison of the efficiencies, because it is the economic cost that we have to consider. If we are going to use the gas turbine as the buffer, the only possible fuel, I take it, is oil, so that the comparatively slight gain in thermal efficiency from the use of the gas turbine could easily be offset by the additional cost of the oil used as an alternative fuel, as compared with coal or coke breeze which quite a number of the more efficient people are using very successfully.

One of the author's points is space requirements in the blast furnace. If we were seriously to get down to a gas turbine-driven job, with the turbine immediately adjacent to the furnace, I think one could not visualise any blast furnace operator being willing to accept those conditions unless he had a stand-by unit, so that the amount of ground which could be saved immediately adjacent to the furnace would be comparatively small. The large volume taken up by the Cowper stoves is mainly up in the air, and the ground space savings would not be as appreciable as the author so glibly states in the paper. On

the other hand, when the author mentions the oil fuel storage, I think he places too great emphasis on the snags of having two separate storage systems. As a rule the steel plant will be a considerable way from the blast furnaces, and in any case, under present oil availability conditions, they would find very strong objections from the oil suppliers to using a low sulphur open-hearth oil for firing of turbines and supply of blast power.

Mr. P. Boel (The Boel Steel Works, Belgium) : With regard to the blower, the blast-furnace operator will demand a blower that is capable of producing a high volume of air at the high pressure, but his normal operating point will be for a high volume of air at a lower pressure, and therefore the blower will be nearly always operating at a point 15 per cent or 20 per cent below his maximum point. For an engine like a blast-furnace blower that works all the year round, a slight decrease in efficiency represents a considerable amount of money at the end of the year, and therefore the blower and the whole machine must work at maximum efficiency at a point about 10 to 15 per cent below its maximum power. The gas turbine, being based on the axial blower, has about its maximum efficiency at a very high driving rate, and when it is slowed down its efficiency goes down markedly. In the case of the blower the problem is not very difficult to solve, since one can add a recuperation turbine behind and recuperate the little loss in power ; but from the point of view of the turbine the gas turbine will be operating below its maximum efficiency point. I therefore do not believe that a variable-speed gas turbine is the ideal solution for driving a blower unless it is put in a combined system, as has been designed for one of the steel plants in Belgium. In that case they have taken a constant-speed gas turbine on which there is on one side a blower and on the other side an electric generator. The second point on which I should like to speak is the very interesting idea of the recuperation of the heat lost in the gas turbine. The temperature within the gas turbine itself is limited by the quality of the steel, and, as the author has stated in the paper, is limited to about 650 deg. Cent. In our country we work with much higher blast temperatures ; our average blast temperature is around 850 deg. Cent., and therefore the recuperator would not be possible. It is indispensable, if you consider the use of a gas turbine, that you recuperate as much as possible of the heat lost. These recuperators are a very important part of the capital cost. I should like to put to you an idea which has been arrived at by one of the big manufacturers of gas turbines on the Continent. As we saw from the curves on the author's diagrams, one has to add quite an appreciable amount of air in excess of the combustion requirements to maintain the temperature at the limit of 650 deg. Cent. required by the gas turbine. The combustion air, when it comes out, can pass through a very simple recuperator and go on. As far as we can work it out, the oxygen contained in the waste air is very high ; there should be about 17 per cent of oxygen. I wonder whether that air, instead of having to be driven through recuperators, could be used, in view of that considerable amount of oxygen within it, as a source of hot air for the combustion of the gas within the stoves. One would in that way be able to utilise not only the waste heat of this combustion air, but equally be able to decrease the amount of gas required in the stoves and at the same time be able to maintain in the stove the very high temperature that we feel is economically advantageous.

Mr. G. C. R. Mathieson (Power Jets, Ltd.) : The first point I should like to raise is the one on comparative efficiency. I cannot quite agree that this is a sound point as made. The gas turbine shaft efficiency is not likely to be greater than that of the steam plant. At the moment we are tending to restrict maximum temperature to 650 deg. Cent., and so the efficiency is not likely to be much in excess of 22·5 per cent, unless the cost of the gas turbine is increased by high-pressure ratio or costly heat exchange apparatus of high effectiveness. Steam plant at 600 lb per square inch and 700 deg. Fah. should give a shaft efficiency of 22·5 per cent and at 850 deg. Fah. an efficiency nearer 26·5 per cent. Pressures and temperatures are going up on new designs of steam plant, and so with temperatures going up on gas turbine plant the efficiencies should hold about level. What is important is the cardinal point of the high-temperature level of exhaust available for blast heating in the gas turbine cycle. Since the duty required here is one of both pressure and temperature increase, the effective efficiency of the gas turbine in pressure plus heat output is much greater than its pure shaft efficiency. In the combined heating and blowing cycle quite a fair proportion of the heating of the blast air takes place in the heat exchanger at the gas turbine exhaust, and so the effective efficiency based on shaft output and heating is around the 50 per cent mark (54·5 per cent according to my calculations) as opposed to the 23·5 per cent based solely on shaft output (27·4 according to my calculations). The same stratagem is not possible with the steam plant, as the temperature at outlet from the boiler or the turbine is not high enough for effective heat transfer.

The incorporation of the air heater in the circuit so that the stack losses are made use of in the turbine is a further feature which improves the efficiency of the cycle. Here, once again, I would suggest that the author has been a little unfair to the conventional system. I am open to correction, but I would suggest that an efficiency of 80 per cent for the stoves is possibly rather low, an efficiency of 90 per cent being the sort of figure a good stove arrangement can attain, but, even so, there is a saving of what would otherwise be a 10 per cent loss. In a Power Jets comparison of overall efficiency of blowing and heating in which the blowing conditions are taken as 25 per square inch gauge and 750 deg. Cent. the combined blowing and heating efficiencies of steam and gas turbine are 61·9 per cent and 68·5 per cent respectively, showing a smaller differential due to assuming better steam blowing conditions and more pessimistic gas turbine conditions. To be offset against this reduced differential, however, there is further saving in the gas turbine plant due to no water charges and reduced labour and maintenance costs. Also the quality of the blast (pressure and temperature) has an influence on the relative efficiency values. So much for the savings in running costs. Now to consider possible savings in capital costs. In this connection, I should like most strongly to endorse the point that it is time we gave real practical force to the modern developments in heat exchanger practice. Our investigations have shown that it is perfectly practicable to construct an air heater to heat the blast air to 750 deg. Cent. using existing materials at a cost of about 12s. per cubic foot per minute as opposed to a cost of about £3 10s. per cubic foot per minute for stoves, or £1 10s. per kilowatt heat output as opposed to about £9 per kilowatt heat output ; even in spite of having to use expensive high-temperature materials at the hot end. There is thus very great scope for capital saving by using metallic heaters in place of the brick heaters at present employed. The other important capital item is the blowing set proper, and here it is difficult to say with any conviction that the gas turbine plant is cheaper than the steam plant—for blowing only, that is. Much effort must go into cheapening the gas turbo-compressor set.

Mr. C. Ungoed (Steel Company of Wales) : One thing that seems to worry the author in the combination of the cycle heat exchanger and the gas turbine is the cycle heat exchanger. Throughout the paper the author has referred to it as recuperative. Has he considered using a rotary regenerator for this piece of apparatus, as it seems to have greater possibilities in space saving and, if used of ceramic material, would probably have better characteristics as far as being self-cleaning is concerned. I do not think that the question of inter-gas sealing would be of great difficulty, as the pressure difference will not be very great. I rather favour this idea to that of the recuperator heat exchanger, owing to the pressure which the latter imposes on the exhaust of the gas turbine, which rather reduces efficiency.

Mr. D. M. Smith (Metropolitan-Vickers Electrical Company, Ltd.) : So far as the mechanical design of the plant is concerned, the author has made out a good case from a performance point of view for the single line plant at variable speed with separate axial flow blower. I would add that in my opinion there is a good case also for a plant of that kind from a mechanical design point of view, because the speeds of the various components fit in well with one another and they also fit in, at least as far as the gas turbine plant is concerned, with gas turbine plant which might be designed for other applications. I think that in these respects the plant described by the author has advantages both over the tapped regenerative scheme, on the one hand, and over a gas turbine plant driving a centrifugal blower, on the other hand.

Mr. F. C. Evans (Metallurgical Engineers, Ltd.) : I am not an expert on gas turbines, but I have been associated with the design of heat exchangers for several schemes of blast furnace blowing. As I see it, the successful development of a gas turbine blower for blast furnaces depends on the development of a suitable heat exchanger. I think there is evidence in the paper that the rather complicated system which the author suggests in his Fig. 6 is partly due to limits on heat exchanger design. On at least one of the schemes that we have studied the heat exchangers have certainly been much larger and nearly as costly as the turbine itself, which gives some idea of the problem.

Mr. T. P. Everett (Richardsons, Westgarth (Hartlepool), Ltd.) : I heartily endorse the author's views that the time has now come for the iron and steel industry to take the plunge and use the gas turbine for blast furnace blowing. You will probably all know that at least one steel works in this country is installing a unit for power generation, and whether the next unit should be for combined power generation and blast furnace blowing or for blast furnace blowing alone is something which I, personally, do not feel competent to advise on. I agree with the author that the single-shaft unit is the right one. To go to two-shaft arrangements, while undoubtedly there would be quite considerable advantages from part-load operation point of view, would increase the capital cost, I am afraid, so that the scheme would become quite unattractive.

(*To be continued*)

Coal Preparation Plant at Lynemouth Colliery

A coal preparation plant installed at the Lynemouth Colliery in Northumberland as part of an extensive reorganisation scheme is designed to treat up to 800 tons of run-of-mine coal an hour. It is the largest plant of its kind yet built in this country and incorporates "Ridley-Scholes" equipment for large coal treatment, "Acco Baum" washboxes for small coal and "Unifloc" equipment for slurry treatment.

ONE of the largest pit modernisation schemes being carried out by the National Coal Board is at Lynemouth Colliery, Northumberland, where, under an extensive underground reorganisation scheme, intensive mechanised mining is being introduced to increase output. For this work the deepening and widening of the Lynemouth shafts was necessary to concentrate the outputs of the extensive undersea workings of both Lynemouth and the adjacent Newbiggin collieries. As part of the associated surface modernisation plan a major step was the development of a complete coal preparation plant to treat the whole of the output which is planned to increase to 8000 tons per day from the Lynemouth shafts plus nearly 4000 tons per day from the nearby Ellington Colliery. A new coal preparation plant, introduced for this part of the scheme, has been designed and constructed by Mitchell Engineering Group, Ltd., to deal with the total output of nearly 12,000 tons per day of run-of-mine coal. With its designed capacity of 800 tons per hour this plant, an aerial view of which is reproduced on this page, is the largest of its kind in operation in Great Britain.

As coal from several seams of different character had to be treated and coal up to 8in in size had to be washed, it was decided that the dense medium method of washing would be required. The washing system decided upon incorporates the Ridley-Scholes "float and sink" system for treating the 8in-1½in coal; "Acco Baum" washboxes for treating the 1½in-0·5mm coal, and the "Unifloc" froth flotation system for treating the slurry.

The plant has been designed so that the large coal and small coal washing sections are substantially balanced, each dealing with about half the total load. The layout is so arranged that the whole output is treated in two plant sections, each of 400 tons per hour capacity, and designed to operate independently. The sections handling large coal and small coal are arranged at opposite ends of the plant with the flow towards the centre, where the washed products meet and are conveyed to the screening and loading plant over the railways at the side of the main building. This layout has provided the flexibility of operation which is necessary in such a large plant and has avoided the need for very high plant buildings.

The plant is fed from a central 200-ton surge bunker which receives the raw coal from the Lynemouth shafts by belt conveyors and wagon-borne coal from Ellington Colliery. Coal is delivered into the plant from the bunker by electric feeders serving two belt conveyors, each of 400 tons per hour capacity. These belts feed two slow-speed scalping screens which remove the lump coal above 8in, which is hand-cleaned on a picking belt. The scalping screens deliver the 8in-0in coal to four high-speed screens which separate at 1½in. These four screens deliver the 8in-1½in coal direct into four Ridley-Scholes primary baths while the 1½in-0in coal passes into bunkers beneath the screens. These bunkers which provide 200 tons storage capacity between the large coal and small coal washing sections.

Large Coal Washing—Ridley-Scholes System

As can be seen from the diagram reproduced in Fig. 2, the Ridley-Scholes dense medium process employs a magnetite medium in a shallow separator in which a rubber belt for the transport of "sinks" forms a slowly moving floor. Since the conveyance of the sinks is due to their frictional grip on the belt, only material denser than the medium can remain upon it. The belt thus promotes efficient separation as well as providing a means for transporting the sinks from the tank.

The magnetite medium is used in the bath under substantially "stable" or "uniform density" conditions, the stability being maintained partly by control of the coal and clay content of the medium and partly by longitudinal flow of the medium in the tank. The medium is recuperated by gravitational settlement and the circulating system is very simple. A simplified flow-sheet of the Lynemouth plant can be seen in Fig. 3.

Primary Separating Baths

The 8in-1½in coal is fed by four bath feed screens to four Ridley-Scholes primary dense medium baths in which float and sink separation takes place at a specific gravity to suit the character of the coal treated, which is usually 1·4 S.G.

One of these baths can be seen in Fig. 4; it consists of a longitudinally tapering tank containing magnetite liquid medium of the density required for separation. The floor of the tank, which is inclined and transversely troughed, is formed by an endless troughed rubber belt which enters through rubber seals in the end wall and slowly travels along the length of the tank to deliver at the shallow end. The return run of the belt is beneath the tank, where the driving gear is situated. The carrying flight of the belt is thus the only moving element in the liquid and true float and sink separation takes place without any mechanical disturbance.

The liquid medium flows steadily from the deep to the shallow end of the tank and the coal to be separated is fed into the deep end and travels with the stream of medium. Reciprocating paddles are used to assist the floating coal in its travel along the surface of the liquid, and this coal is discharged together with flowing medium over a weir into a transverse trough, along which it floats to a discharge trough at the side of the bath. The dirt and middlings sink through the liquid medium on to the moving belt and are conveyed out of the tank and over a discharge pulley at the shallow end on to a refuse drainage and spraying screen. The discharge pulley of the belt has means of vertical adjustment so that the amount of medium discharged with the dirt can be controlled and the components of flow in the bath adjusted.

Medium Drainage and Spraying Screens

The coal discharged with flowing medium from the baths is floated along curved troughs to drainage screens situated alongside the baths. These screens are inclined and have 1mm wedge wire decks through which the medium drains to surge tanks for recirculation. The coal travels

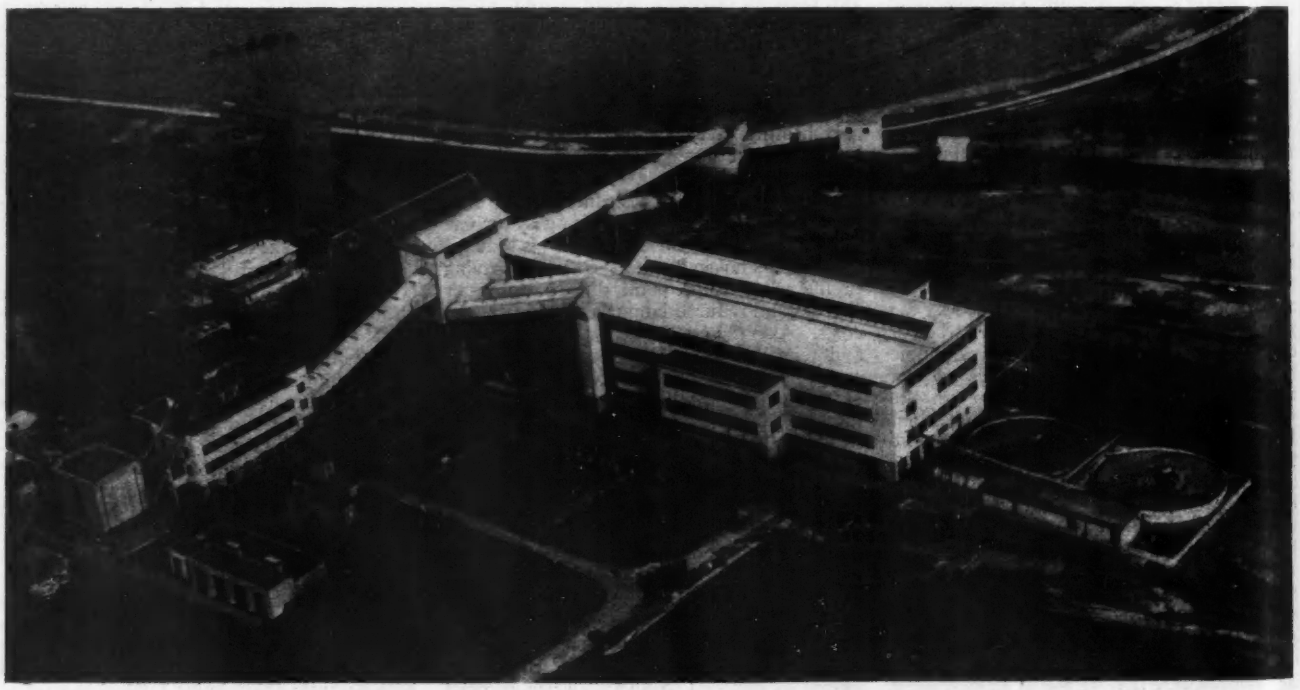


Fig. 1—Coal preparation plant at Lynemouth. The plant has a capacity of 800 tons per hour and is capable of handling coal up to 8in in size from various seams

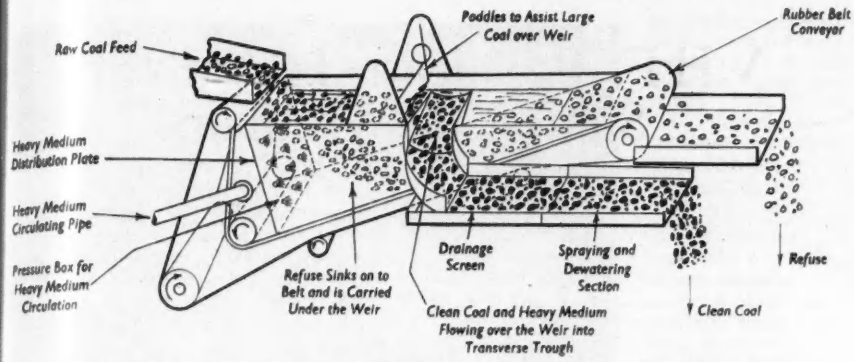

Paddles to Assist Large Coal over Weir
Rubber Belt Conveyor
Raw Coal Feed
Heavy Medium Distribution Plate
Heavy Medium Circulating Pipe
Pressure Box for Heavy Medium Circulation
Refuse Sinks on to Belt and is Carried Under the Weir
Drainage Screen
Spraying and Dewatering Section
Refuse
Clean Coal
Clean Coal and Heavy Medium Flowing over the Weir into Transverse Trough

Fig. 2—Diagrammatic arrangement of Ridley-Scholes dense medium coal washing process

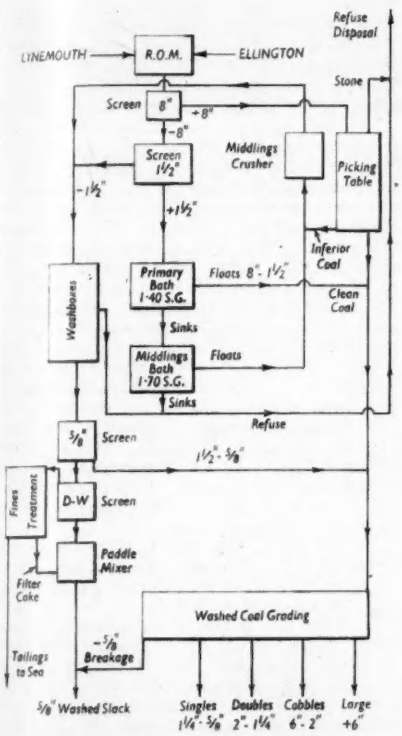


Fig. 3—Simplified flow sheet

over these screens to subsequent spraying screens which have primary and secondary batteries of sprays above them. For the primary sprays partially cleaned water overflowing from the thickeners is used and for the secondary sprays clean make-up water. The coal having been cleansed of adhering medium is conveyed to the sizing and loading plant. The diluted medium which is drained through the spraying screens is collected in a tank and delivered by rubber-lined pumps to a recuperation system. The sinks from the primary bath belts are delivered to two drainage screens, where the medium drained is returned to surge tanks.

Secondary Separating Baths

The low gravity separation carried out in the primary baths is necessary to produce the high quality coal in the larger sizes. This separation results in sinks products which consist of "middlings" as well as refuse and these sinks are fed to a secondary Ridley-Scholes bath.

One secondary bath serves each pair of primary baths, and they operate with medium at a high density—normally 1·7 S.G. The floats, which consist of middlings between 1·4 S.G. and 1·7 S.G., pass from each bath to a drainage and spraying screen. These middlings are then crushed below 1¼in and mixed with the 1¼in-0in raw coal for treatment in the small coal washery. The sinks from the secondary baths consist only of high ash shale, and after they are drained and sprayed are delivered to the main refuse disposal conveyor.

Bath Medium Circuits

Each of the four primary and two secondary baths has its own medium circuit, surge tank and pumping system. In each circuit the medium from the drainage screens passes to the respective surge tank from which it is pumped back to the bath feed inlets. Each surge tank has sufficient capacity to hold the total contents of its bath, together with a working reserve.

The densities of the bath circuits are maintained by control of the medium returned from the thickeners, which are automatically controlled to deliver high and low density media, respectively, to the secondary and primary baths. Bath densities may thus be increased by setting an automatic control means to a higher value, whilst a quick increase may be made by introducing high-density new medium. Reduction of density of any bath circuit may be made quickly through water dilution valves.

Dense Medium Recuperation

The diluted medium resulting from the spraying of the washed coal, middlings and refuse is pumped to two independent magnetite thickener systems. Each of the thickeners is preceded by three fine-mesh slurry screens which remove any coarser particles of coal or shale. Liquid from the slurry screens is classified in the thickeners, the heavy magnetite settling quickly while the lighter coal and clay slimes pass into the overflow.

This overflow, carrying about 5 per cent of slimes, is fed to the primary sprays on the spraying screens for preliminary washing purposes, a portion of it being bled from the system to balance the build-up of solids. The magnetite is extracted from the thickeners by oscillating ball valve mechanisms which are operated by automatic density controls.

Each of the thickeners has an automatic density control consisting of a weighing machine which continually weighs a constant volume of the discharged medium in a cone vessel designed to keep the medium in motion and prevent settlement. The density of the weighed medium is continuously indicated and the settings of two pointers at two given densities determines whether it passes to the secondary or to the primary surge tanks (Fig. 5). If the density of the discharged medium falls below that indicated for the primary baths, the discharge from the thickener automatically stops for a given time to allow a quiescent settling period. After a predetermined time discharge automatically restarts and the medium is again delivered according to the indicated density, or discharge is again stopped. All the controls in this equipment are operated electrically by mercury switches actuating contactors with time relays, enclosed in separate control panels.

The medium extracted from the bath circuits

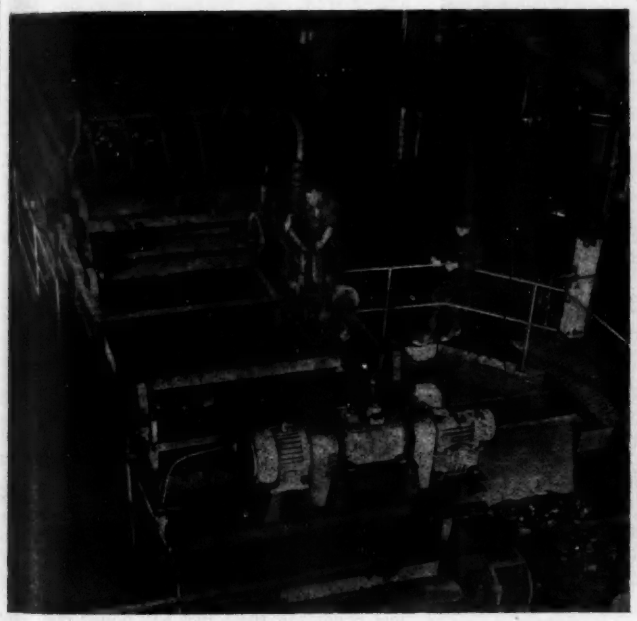


Fig. 4—Ridley-Scholes dense medium separation bath from shallow end, with separated coal in discharge conveyor on the right of the tank

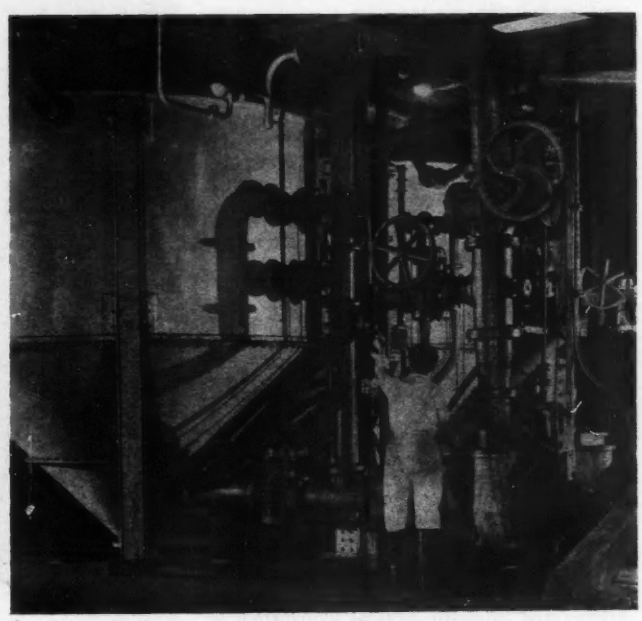


Fig. 5—Dense medium surge tanks and circulating system. According to its density the medium is passed to the primary or to the secondary tanks

on the products is thus recovered and returned at a density at least as high as that required. In the event of any rise above this value, which can only occur very slowly, water valves are operated to dilute the medium.

Two continuous wet ball mills, operating in closed circuit with classifiers, prepare newly-ground magnetite to replace working losses. These mills grind magnetite finer than 200 mesh and deliver to a small thickener. This thickener delivers a high-density medium of about 2 S.G. to a storage tank where it is held in reserve, ready for pumping to any of the surge tanks when required.

Small Coal Washing—"Acco Baum" Washboxes

The 1½in-0in raw coal is delivered from the storage bunkers by electric feeders and fed by belt conveyors to the small coal washing section. In this section are four "Acco Baum" washboxes equipped with automatic controlled shale discharge. Washed coal from the washboxes is delivered to four sizing screens which extract the 1/2in-0in coal and wash water, and feed the 1½in-½in washed coal to the main washed coal conveyor which collects the large coal from the Ridley-Scholes section for delivery to the sizing and loading section.

The ½in-0in coal is drained on four wedge wire screens which deliver the ½in-0·5mm coal to the slack conveyor. Wash water drained by these screens is delivered to a "spitzkasten" on the ground floor of the building from which the overflowing clarified water is delivered to the pump sump. The refuse discharged is conveyed to the main refuse belt to join that from the large coal washery.

Slurry Washing—"Unifloc" Froth Flotation System

The thickened slurry from the "spitzkasten" is pumped to particle-size control headboxes which deliver a feed of wash water containing 0·5mm-0mm coal to two conditioners where oiling and mixing take place. The slurry is first cleaned in two banks of primary froth flotation cells from which the clean froth is delivered to two banks of secondary cleaning cells which deliver clean frothed coal. This coal is dewatered on four "Unifloc" string discharge vacuum filters and the filter cake is collected on a belt conveyor which delivers it to the washed slack conveyor.

The tailings from the primary and secondary cleaning cells are delivered to a "Unifloc" clarification plant which has two thickeners in which the tailings are flocculated and settled. The thickened tailings are extracted by high-pressure diaphragm pumps which pump the sludge to the sea by pipeline—a distance of about one-third of a mile.

Washed Coal Sizing and Loading

The washed coal is delivered by belt conveyor to a sizing plant which is situated above the rail sidings adjacent to the main building. This sizing plant has two separate banks of screens which can run independently and feed on to the belt boom loaders used for loading wagons. The sizes of coal produced are: plus 4in, 4in-2in, 2in-1½in and 1½in-½in. Washed slack and filter cake are delivered to a paddle mixer which intimately mixes the filtered slurry with the washed coal and delivers the ½in-0in product to two roadways by chute.

Pit stone from the Lynemouth shafts is delivered by a conveyor to a central refuse loading point. The refuse conveyor from the washery also delivers to this conveyor and there are arrangements for loading refuse on railway wagons, or, alternatively, to dumper cars for disposal to a coastal pit heap.

The whole washing plant and gantries and bunker, are housed in modern buildings designed to harmonise with the rest of the colliery extensions. The washery buildings are steel-framed and sheathed with asbestos sheeting of troughed section and having a reinforcing lining to give adequate strength with heat insulation. Large areas of glazing are arranged to give good natural lighting and extensive artificial illumination is provided by fluorescent strip lights. The plant is heated and air-conditioned by steam unit heaters.

V.H.F. Broadcast Transmitting Station at Wrotham

The opening of Wrotham v.h.f. transmitting station by the Postmaster-General on May 2nd marked the first step in the B.B.C.'s plan for v.h.f. coverage of Britain. Wrotham transmits the Home Service, Light Programme and Third Programme in parallel with the existing long and medium wave stations. It brings the advantages of a v.h.f. service to a potential audience of about 13,000,000 listeners in Greater London and the south-east of England. Among these improvements are reduced radio interference, particularly from abroad, extension of coverage to some areas hitherto poorly served and inherently improved quality because of increased bandwidth in the receiver.

WROTHAM v.h.f. transmitting station is the first of ten stations designed by the B.B.C. to give a v.h.f. broadcasting service, with its extended coverage, reduced interference and improved quality. It will be recalled that in recent years the service given by the existing medium and long-wave broadcasting stations operated by the B.B.C. has been restricted by the limited number of wavelengths available for broadcasting within the United Kingdom. Moreover, interference from foreign stations has drastically reduced the coverage, particularly of the Home Service, in many parts of the country. This situation had long been foreseen by the B.B.C. and as long ago as 1945 the research department began a series of tests, to get first-hand information on the possibilities of broadcasting on very high frequencies (v.h.f.). As a result, it was decided, as a long-term project, to carry out comparative tests at high power.

To this end the Wrotham experimental station was built in 1950, just off the main London-Folkestone road, some 20 miles south-east of London. It comprised a single-storey brick building and a 470ft mast, the base of which is 730ft above sea level. The station was equipped with a 25kW frequency modulated (F.M.) transmitter and an 18kW amplitude modulated (A.M.) transmitter, both built by Marconi's Wireless Telegraph Company, Ltd., and, from July, 1950, until March of this year, has been radiating on v.h.f. a series of F.M. and A.M. signals. As a result of experience gained from these full-scale experiments, the B.B.C. decided that it would be in the interests of the public to use F.M. for sound broadcasting in the v.h.f. band; this recommendation was subsequently endorsed by the Television Advisory Committee, whose second report, published early in 1954, dealt solely with v.h.f. sound broadcasting.

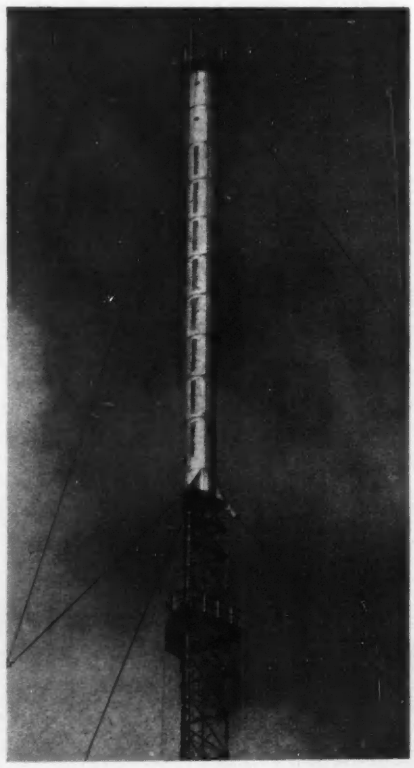


Fig. 1—The v.h.f. aerial, which is shared by the transmitters, is an omni-directional slotted cylinder array. The cylinder is 110ft long and 6ft in diameter, the thirty-two slots being arranged in eight tiers

On the basis of its information and the experience provided by the prolonged tests from Wrotham, the B.B.C.'s Engineering Division put forward a scheme for providing a frequency-modulated v.h.f. service which would cover some 98 per cent of the population. This scheme was divided into two parts. Stage I, which will cover the main centres of population as quickly as possible and bring a v.h.f. service to about 83 per cent of the population, comprises five high and five medium-power stations; it was approved by H.M. Postmaster General in July, 1954, and work is in hand. Stage II, which will require about sixteen further high, medium and low-power stations, has not yet been approved. The remaining stations in stage I will be at Pontop Pike (N.E. England), Divis (Northern Ireland), Meldrum (N.E. Scotland), to be completed this year; and Norwich, Dartmoor, Holme Moss, Sutton Coldfield and West Wales, to be completed in 1956.

At Wrotham, the original transmitters were designed so that they could be adapted to work as either F.M. or A.M. transmitters, depending upon the outcome of the tests. In fact, the A.M. transmitter was converted to F.M. in January, 1954. Since the end of the experimental transmissions in March, 1955, work has been in progress at Wrotham to install additional transmitters and carry out modifications to those already on site, together with the associated aerial, drive, programme input and other auxiliary equipment.

The existing transmitters, known as FM1A and FM2A, will normally carry the Light and Third programmes, respectively; they are backed up by two new 4·5kW transmitters, FM1B and FM2B, which will act as spares. Two further new transmitters, FM3A and FM3B, each of 10kW output, will operate together and carry the Home Service. The layout and design of the equipment for the Home Service transmitters has been so arranged that they will, ultimately, be automatic in operation. Certain ancilliary equipment common to all three services will also be automatic.

The output and combining arrangements of these six transmitters are unusual and interesting. In the case of the first two pairs, the failure of the normal transmitter is covered by the reserve, manual switching of the outputs and application of power to the reserve being necessary. The outputs of whichever transmitters of these two pairs are operating are fed to a combining circuit, at the output of which the Light and Third programmes appear as a combined signal. This output is then split into two halves, each half being fed to one section of a further combining circuit.

The output of each 10kW Home Service transmitter is arranged to feed the other section of this combining circuit. Thus, at the outputs of the second combining circuit the signal appears as two half-power combinations of Home, Light and Third signals, and under normal conditions these two half-power combined signals are taken over separate feeders to the two halves of the aerial system (Figs. 1 and 2). By this means the effect of faults developing in

Fig. 2—Interior of cylindrical section of the mast. The framework of bars forms a screen behind the slots and serves to increase the bandwidth of the aerial. All the slots are fed with currents in phase and of equal amplitude via concentric feeders

the transmitters is reduced to a minimum and the failure of any one transmitter or of one-half of the aerial would be almost undetected except by listeners on the fringe of the service area. In addition a very comprehensive emergency switching installation is provided to guard against the failure of the various combining circuits and the aerial system.

Duplicate FMQ drives are installed for each service and they are fed simultaneously with the programme. Automatic changeover arrangements ensure that either drive may be selected, with the other acting as spare. The "FMQ" system of frequency modulation was developed by Marconi's Wireless Telegraph Company, Ltd., and comprises a quartz crystal oscillator connected through a quarter-wave network to a balanced modulator, the susceptance of which varies with the modulating signal, and in turn varies the frequency generated by the crystal oscillator. The crystal is specially cut so that it does not produce spurious harmonics within the operating range. The chief advantage claimed for this system of frequency modulation is that the circuits are simple and easy to maintain.

The output of the crystal oscillator is passed through three stages of frequency doubling and one tripling stage to produce the required carrier frequency. In the case of the two original transmitters FM1A and FM2A there then follow five stages of amplification. The first two are conventional push-pull stages, while the remaining three are single-ended earthed-grid stages with coaxial-line tuning elements. The output stage consists of two BR128 valves in parallel, giving an output of 25kW. Supplies at 6kV and 3kV for the valve anodes are obtained from hot-cathode mercury vapour rectifiers in the power conversion plant which is installed behind the transmitter.

The 4·5kW (FM1B and FM2B) transmitters are generally similar in electrical design to the earlier ones, the first two stages are push-pull and they feed two single-ended earth-grid stages provided with coaxial line tuning elements, one of which forms the output stage.

Except that the new 10kW transmitters (FM3A and FM3B) are much more compact, they follow closely on the design of the earlier transmitters, having two push-pull stages followed by three single-ended earthed-grid stages: these three stages are again provided with coaxial line tuning elements. The final stage has two BR191B valves operating in parallel. All the valve filaments are a.c. heated. As illustrated in Figs. 3 and 4, each of the Marconi 10kW FM transmitters is housed in two standard cabinets, each 5ft wide, 2ft 6in deep and 7ft high. The left-hand cabinet (viewed from the front) normally houses the drive unit and its power supply, the main h.t. rectifier, the auxiliary h.t. rectifier, all contactors and fuses, as well as the first and second r.f. amplifier stages. The right-hand cabinet contains the third, fourth and final r.f. amplifier stages, together with a "Reflectometer" and a magnetic amplifier unit. The function of the "Reflectometer" and magnetic amplifier is to verify the matching between the transmitter output impedance and the feeder system. Should an attempt be made to bring the transmitter up on power with a serious mismatch obtaining in the system, or should a mismatching fault develop during transmission, a relay in an associated magnetic amplifier operates, breaking the control supply circuits and thereby bringing the overload protection circuits into action.

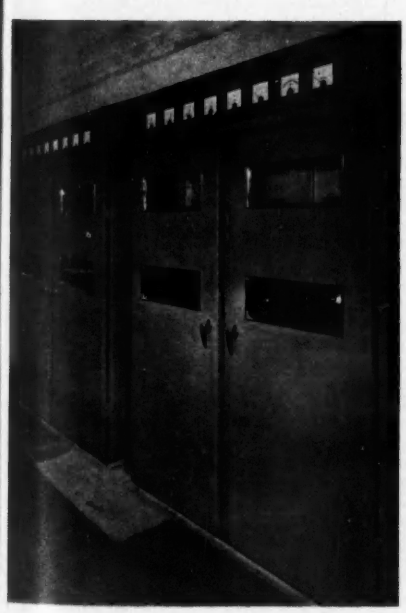


Fig. 3—The first of the two 10kW Home Service transmitters at Wrotham. The second 10kW transmitter is due to go into service later this year

The transmitter is designed for operation in the frequency band 88–108 Mc/s. It is air cooled throughout. Electro-mechanical interlocking of the doors ensures that they cannot be opened until all high-voltage supplies have been removed, and conversely that the supplies cannot be reconnected until all doors are interlocked. Power supplies to the transmitter can only be switched on in correct sequence. Adequate overload protection is provided and all important valve leads are fully metered.

All six transmitters use air-cooled valves. The cooling system of the 25kW transmitters serves a dual purpose, in that air is drawn from outside, filtered, passed through the transmitter cabinets and then is either exhausted to atmosphere or recirculated within the building for heating in cold weather. The recirculation system is fully automatic and controlled by thermostats. In the case of the 10kW transmitters the air is drawn from within the building and exhausted to atmosphere whilst the 4·5kW standby transmitters are cooled by air circulation entirely within the transmitter building.

Since the transmissions are automatically monitored at Broadcasting House, no master control position is installed at Wrotham. If, however, a programme fault occurs an alarm will be given on the alarm and indication panel in the control room. This panel is equipped with a series of lamps indicating the condition of the various transmitters, drives, supplies and other auxiliary equipment associated with each programme. Any faults involving plant or equipment at Wrotham will be automatically indicated so that the appropriate action can be taken.

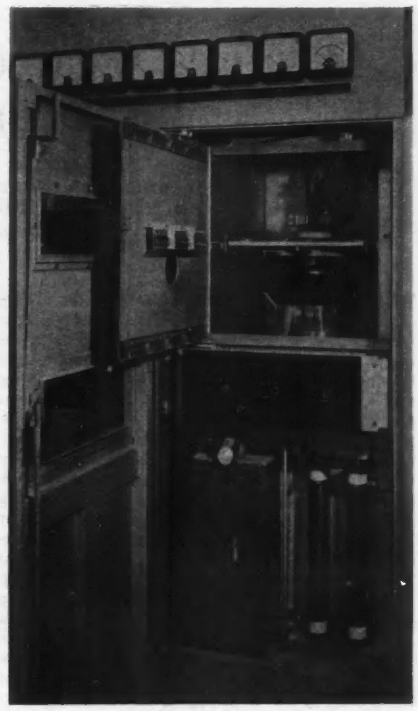


Fig. 4—One half of the 10kW, F.M. transmitter output stage, which consists of two BR128 valves in parallel in an earthed grid circuit

Provision is included for the unattended operation of the Home Service transmitter in the early morning. For normal daytime operation three automatic monitors, of B.B.C. design, are installed at Broadcasting House, London, and they will compare the outgoing programmes with those received by radio from Wrotham; they are arranged to give an alarm at Wrotham in the event of programme faults being detected. For operation during the early morning, however, changeover panels are provided at Wrotham and Broadcasting House which, when switched to the appropriate position, transfer the Home programme monitor alarms to Broadcasting House. At the same time this permits the Home programme to be sent to Wrotham by either the normal line and programme input equipment or by the Third programme line and its associated programme input equipment (which are not normally required for the Third programme until the evening).

Power for the station is supplied at 11kV, three phase, 50 c/s by duplicate feeders. Only one feeder is normally connected to the e.h.v. busbars, but in the event of the supply failing the second feeder is automatically connected. The supply is transformed to 415V by duplicate 500kVA transformers, either of which can carry the full load of the station. These transformers are normally operated in parallel on both the e.h.v. and l.v. sides so that a failure of either transformer would not deprive the station of power. The distribution from the low-voltage a.c. switch room is split between the transmitters, drives and programme input equipment so as to provide regulated and unregulated supplies as required. In the event of a voltage regulator failure, however, the equipment normally operated from it can be transferred to an unregulated supply. As far as possible the power supplies for the transmitters and associated equipment for each programme service have been kept separate to minimise the effect of mains failure. Two 50V d.c. supplies for the transmitter control circuits are obtained from metal rectifiers and there is a 240V battery for emergency lighting.

Oil-Fired Geared Steam Shunting Locomotive

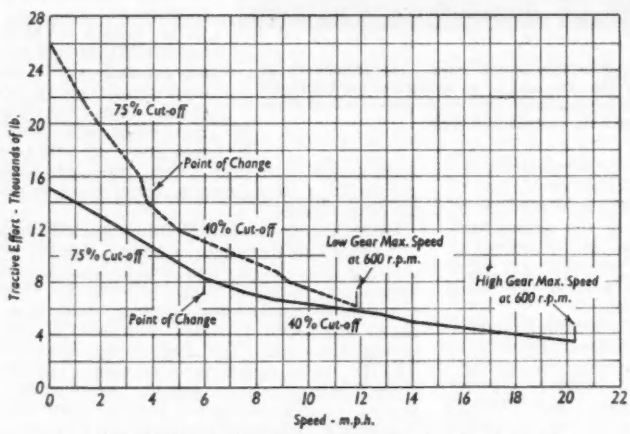
A new design of 0–6–0 steam shunting locomotive has been developed by Sentinel (Shrewsbury), Ltd., for heavy industrial duty. It is of 200 h.p., weighs 50 tons and has a starting tractive effort of 26,000 lb. In this locomotive the makers have introduced oil firing, all-geared transmission, roller bearing axleboxes, steam braking, and all parts are designed for accessibility and interchangeability.

TRIALS were recently completed on the prototype of a new design of 200 h.p. steam shunting locomotive at the works of Sentinel (Shrewsbury), Ltd., and eleven of the locomotives are now under construction—eight for Dorman, Long and Co., Ltd., and three for Guest Keen Iron and Steel Company, Ltd. This new 0–6–0 locomotive weighs 50 tons and, although it is in many respects similar to the shunters made by the firm for a number of years, it incorporates several noteworthy new points in design to bring it into line with modern practice and to suit it for its particular duties in heavy industrial operation. Like all Sentinel locomotives, it is designed to work at specific shunting speeds and develop maximum power at these speeds. In low gear the locomotive has a starting tractive effort of 26,000 lb and a tractive effort of 5720 lb at the maximum speed of 11·8 m.p.h. In high gear the starting tractive effort is 15,100 lb and at the maximum speed of 20·3 m.p.h. the continuous tractive effort is 3330 lb. The power available is more than sufficient for the locomotive to haul a 1400-ton train of ordinary wagon stock on level track. The torque characteristics of the locomotive can be seen in the accompanying diagram.

The general arrangement of the new locomotive can be seen in the photograph and drawings reproduced here. Its box-section chassis frame has 2in thick steel side members, and 3in thick steel buffer beams extend down to within 8in of the rails. Cast steel axle horn guides faced with manganese steel on the wearing surfaces are dowelled and riveted to the frame. The axles on which the disc wheels are mounted inside the frame members are carried in Timken roller bearing axleboxes supported by heavy duty laminated springs. Drive is transmitted to the middle axle, which is coupled through fly cranks and rods to the two outer axles.

In this new design of locomotive the engines are mounted at the front end and the boiler at the rear end, the driver's cab being situated immediately in front of the boiler and separated from the engine compartment by the fuel and water tanks. The engines are a development of the firm's standard high-speed poppet valve vertical design and are arranged side by side.

Each engine has two double-acting cylinders of 6¾in bore by 9in stroke and develops 105 b.h.p. at 500 r.p.m. The poppet valves of the engines are operated by push rods from a camshaft in the crankcase and this camshaft slides in its bearings to adjust the valves for cut-off or for reversing purposes. Two cut-off positions are provided, giving 75 per cent and 40 per cent admission of steam in both forward and reverse and all the valves can be held in the open position at one setting for draining purposes. In this improved engine detachable valve guides are fitted and the valve chests are enclosed by readily detachable lagged casings to reduce heat losses. Each set of valve mechanism is built as an interchangeable unit, so that when valve regrinding or other maintenance work is necessary a spare valve assembly can be fitted and the locomotive can be kept in service. A selector fork and control spindle through which the camshaft is moved is coupled through links and a rod to the reversing lever in the driver's cab. The original method of splash lubrication has been replaced by a pressure lubrication system fed by an integral gear pump. This pump feeds into a distribution box, which via reducing valves supplies high-pressure lubricant to the big-end bearings, low-pressure lubricant to the valve gear and camshafts, and oil to a pocket from which it cascades on to the timing gears and drive. The engines are now supported on the frame and gearbox by self-aligning spherical bearing members.



Tractive effort/speed characteristics of steam shunting locomotive

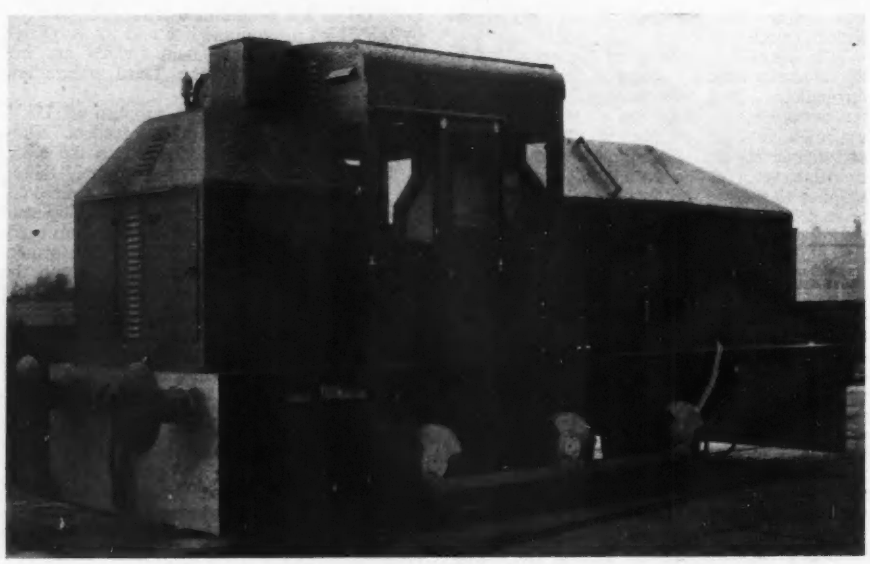
Drive from the side-by-side engines is transmitted to a common gearbox, which has a fabricated steel casing extending across the full width of the locomotive frame. The lower half of this gearbox is dowelled and bolted to the locomotive side members to form a rigid frame stretcher, and it incorporates the self-aligning spherical bearings for the engine bearers. Forged nickel-chrome pinions with hardened and ground teeth on the engine crankshafts are in constant mesh with high and low-ratio gears on the output shaft of the gearbox which is parallel with the longitudinal axis of the locomotive. These output gears are mounted freely on the gearbox main shaft, which is carried on ball and roller bearings. Two internal gear dog clutches splined on the shaft can be moved along the shaft by operation of a lever in the driver's cab to engage either the high or low ratio gears, or set in an intermediate neutral position. Drive from the output shaft of the gearbox is transmitted through a cardan shaft, fitted with a Layrub coupling at each end, to the final reduction gearbox on the centre driving axle of the locomotive. This cardan shaft is located on spigots, and washers fitted in the Layrub couplings facilitate removal of the shaft without need for disturbing the gearboxes.

All of the gears in the main transmission box and those on the engines are clearly marked to ensure their correct phasing in the event of dismantling for inspection or overhaul purposes. A plunger oil pump driven through a cam on the gear shaft and drawing oil from the sump circulates lubricant throughout the box.

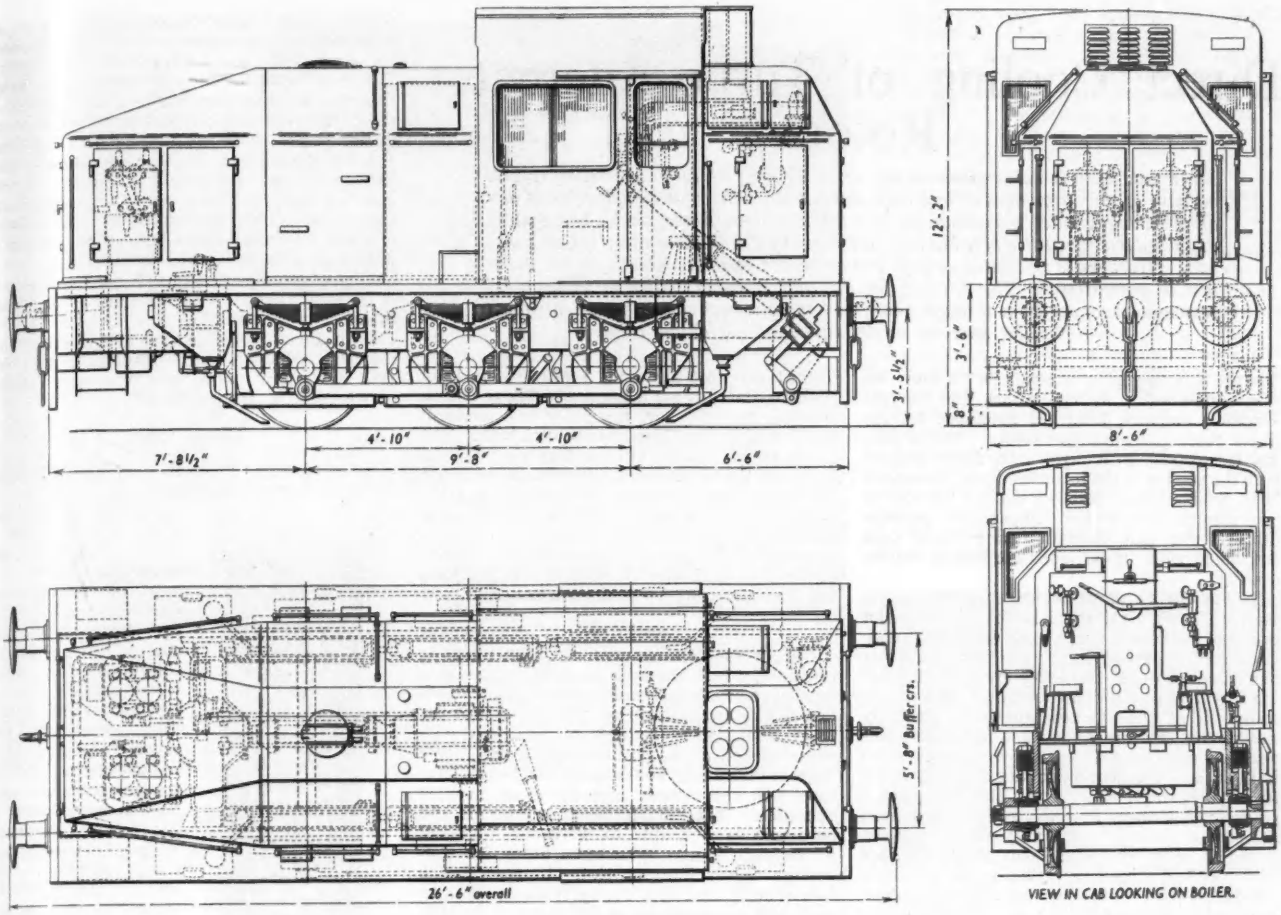
The final reduction gearbox is supported by white metal-lined steel-backed bearings on the axle and it is connected to the main frame by a torque reaction member. The gearbox incorporates bevel input reduction gearing driving the axle through final spur reduction gears. All the gears are of forged nickel-chrome-molybdenum steel with hardened teeth, and the input shaft is mounted on Timken taper roller bearings. The cascade lubricating system of this box incorporates a magnetic filter and is fed by a cam-operated plunger pump. The overall gear ratio is 6·37 to 1 in low gear and 3·7 to 1 in high gear.

The axles are mounted on Timken roller bearing boxes which slide vertically in horn check plates. Torque stay pads carried on the final reduction gearbox move vertically in guides on a ballast weight member which also serves as one of the frame stretchers. With this arrangement the axle and gearbox assembly with the torque reaction members move vertically in unison. The torque stay pads are faced on one side with "Oilite" and on the other with manganese steel and the guides in which they slide are anchored on machined faces on the ballast beam.

In order to provide for the variations in track layout and gauge usually encountered in industrial establishments the manganese liners of the horn check plates are machined to permit up to ⅜in side float each way on the centre axle and $\frac{5}{16}$in each way on the leading and trailing axles. To permit side float of the axles the coupling-rods are fitted with spherical bushes, which are



200 h.p. geared steam shunting locomotive



General arrangement of oil-fired geared steam shunting locomotive

fully floating on the bore and outside diameter and allow up to 7 deg. swing of the rod. These bushes are retained on the crankpin by collars and are designed for quick and easy removal and replacement, their dimensions being such that they can be inserted into the bore at right angles and simply rotated into alignment.

A new design of oil lubricator, which has been developed for the connecting-rod bushes, is designed to cut off the feed of oil when the locomotive is stationary. A float in the oil chamber of the lubricator has a light valve on its stem, which normally seals the oil feed hole. When the locomotive is running the movement of the float is sufficient to open the valve to release an intermittent flow of oil to the bearing. The bushes have three holes drilled through their sides and oil passes through these holes to lubricate the crankpin bore.

Easy access is provided to the engine compartment and main gearbox through large panels on each side and in front of the engine compartment for maintenance and inspection. For major overhaul purposes the engines and top half of the gearbox can be withdrawn from the compartment through a space sealed by removable panels at the top.

The vertical water-tube boiler situated at the rear of the driver's cab is arranged for oil firing by a Laidlaw Drew single burner installation and has a working pressure of 275 lb per square inch. It is fitted with a four-coil superheater giving a maximum total temperature of 750 deg. Fah. The evaporative capacity is 5500 lb per hour and the heating surfaces are as follows : tubes, 92·4 square feet ; firebox, 51 square feet ; and superheater, 53·5 square feet.

The firebox and shell of the boiler are made of welded steel plate and the boiler, which has no foundation ring, is supported by three spaced feet, which register on stools on the cab floor. The firebox incorporates three feet and, after dropping out the combustion chamber, the box can be lowered right out of the boiler with the use of built-in jacking points which are intended to facilitate maintenance and inspection.

The combustion chamber is suspended from seven angle brackets and is about 18in deep. For oil burning purposes twenty-four air tubes are arranged at angles round the base of the chamber. Three tuyeres spaced around the side at the upper part of the chamber provide secondary air for combustion.

The Laidlaw Drew burner projecting through a central orifice at the bottom of the chamber is supported on a trunnion mounting. By simply turning a handle at one side of this mounting the complete burner can be quickly and easily released and dropped out for nozzle cleaning or replacement purposes. The oil fuel line is coupled to one side of the hollow bar on which the burner is mounted, and the steam line to the opposite side. The body of the burner is centralised in the combustion chamber orifice by pegs set at right angles to the line of the mounting bar. A pressure-controlled fuel restriction valve is fitted to prevent too rapid heating of the boiler from the cold condition. If at any time it is required to change over to solid fuel firing, a suitable combustion chamber can be readily fitted to the boiler and the firebox setting changed without need for major alterations to the main structure. The funnel is attached to the boiler top plate and has four inner tubes in its base, each tube being fitted with a combined blast nozzle and blower ring.

The main water tank of 850 gallons capacity and two fuel tanks are situated in the body of the locomotive between the driver's cab and the engine compartment. The main tank for heavy fuel oil is of 300 gallons capacity and is fitted with a thermostatically controlled steam heater. A separate 100-gallon tank holds the light fuel oil used when first lighting the burner. If at any time the locomotive is changed over to solid fuel firing the fuel tanks can be taken out and the casing centre section removed for the compartment to be used as a bunker.

A double-acting boiler feed pump and a non-lifting injector with water control and shut-off valves are fitted and the automatic oil firing gear is carried on the side casing.

In addition to the conventional screwdown brake gear power braking is provided by two 7in diameter steam cylinders mounted on a common shaft which actuates pull rods operating a single brake block on each wheel. The main steam brake valve operates in conjunction with a small supplementary valve, which, when shut, cuts off the supply of steam to the main valve. When the brake valve handle is moved to the open position a cam is first turned and opens the supplementary valve to admit steam to the main valve and on to the brake cylinders. The steam brake cylinders, like the axleboxes and spring gear, are mounted outside the main frames to facilitate maintenance and inspection. A gravity feeding sand box is fitted in front of each of the two leading wheels and behind the two trailing wheels, and duplicated control levers for these boxes are mounted at each side of the driver's cab.

The cab is particularly roomy and has large windows in the front and rear panels and sliding windows in each side to give the maximum possible unobstructed vision during shunting operations. The cab layout is so arranged that without moving from his main controls the driver can see the buffers and maintain a constant watch on the train in all shunting movements in both directions from both sides of the cab.

All parts of the locomotive are designed to give ease of accessibility for maintenance and inspection, and a majority of the main parts, such as the boiler, engines, gearbox and tanks, can be removed in a relatively short time as complete units. With this form of construction it is possible, when operating a number of the locomotives, to keep them in constant service by maintaining a minimum number of spare units, which can be fitted whilst carrying out any necessary repairs or major overhauls.

We are informed that these locomotives can be made ready to go into service from the cold condition in about forty minutes. The fuel storage capacity is sufficient for twenty-four hours' operation without refilling, and the water capacity is sufficient for ten to sixteen hours' working according to the duty.

Direct Cooling of Turbo-Alternator Rotors

Much attention is being given to the direct cooling of turbo-alternator rotors, because of the advantages of improved dissipation of the rotor winding losses and of obtaining greater maximum outputs from a given frame size. The system described and illustrated here has been developed by The General Electric Company, Ltd. Hydrogen is circulated through two circuits in parallel. One is for the stator and is conventional. The other is for the rotor winding, which is made up of rectangular copper tubes through which the hydrogen is circulated by a centrifugal impeller mounted on the outboard end of the rotor.

IN the accompanying illustrations we show the essentials of a system which The General Electric Company, Ltd., has developed for the direct cooling of alternator rotors. The cooling gas (hydrogen) is brought into direct contact with the copper of the rotor windings. Improved heat dissipation is thereby obtained because of the elimination of the temperature gradient through the slot insulation and rotor steel associated with the orthodox method of surface cooling.

In the G.E.C. direct-cooled alternator use is made of straight rectangular tubes for the slot portions of the rotor windings, which are ventilated on a separate circuit, the hydrogen being circulated through the tubes by a centrifugal impeller mounted on the outboard end of the rotor. The stator ventilation is substantially similar to that in a conventional hydrogen-cooled design, except that only one axial-flow fan is fitted and the ventilation ducts are modified to suit the single end entry. The two parallel paths for hydrogen flow will be identified from the general arrangement drawing, Fig. 1, whilst Fig. 2 shows in more detail part of the windings at one end of the rotor, including the gas entry (or outlet) ports in the overhang portion. The slot tubes are connected at both ends by suitably shaped copper strips and these strips are also direct cooled on separate circuits, which are not shown in Fig. 1. This arrangement increases the effective volume of hydrogen flowing through the rotor and reduces both the maximum and mean temperature rise of the windings.

The general arrangement of the conductors in the slots is shown in Fig. 3. The slot itself is parallel-sided and is wider at the top to provide the maximum area for copper and gas ducts. The conductors are hard-drawn tubes of electrolytic copper alloyed with a small proportion of silver in accordance with usual practice to increase the mechanical properties at elevated temperatures. The arrangement of two conductors side by side has the advantage that the number of turns per slot is not reduced compared with a conventional winding, and the increase in excitation current is only moderate. At the same time, gas ducts of reasonably efficient aerodynamic shape are obtained and the mechanical stresses in the copper are low.

As can be seen from Fig. 2, the end connectors are not tubular, but consist of strips which are formed on steel jigs and, whilst clamped in position, the ends are machined to size to ensure accurate assembly on the rotor and uniform support of the windings by the end bells. The conductors are fitted into the slots and the end-connected joints are made in a definite sequence. The connectors are fitted to the bars at right angles, with an interleaved joint secured by silver soldering. This procedure ensures that there is no distortion of the copper and no deterioration of the insulation, which is inserted after the joint has been made and as the winding proceeds.

Insulation

One of the changes that has been made in association with the new winding construction is that a synthetic resin-bonded glass cloth laminate is used instead of "Micanite" for the main insulation; the new material has high electrical and mechanical strength, a reasonable degree of flexibility, and is unaffected by temperatures well above those normally experienced in operation. The surface finish is smooth and hard and is well able to withstand frictional forces such as may arise when fitting the conductors tightly into the slot. In general, the insulation is used in a double thickness both to earth and as a separator in the centre of the slot.

A number of advantages are claimed for the arrangement whereby the hydrogen is drawn from one end of the rotor to the other. It permits the use of continuous slot insulation with normal creepage surfaces, and eliminates any discontinuity or bushings, which are necessary if the gas is drawn in at each end of the rotor and discharged into the gap. Furthermore, the slot and interturn insulation is formed from rectangular strip material contained between continuous flat surfaces. The ports for gas entry into, and outlet from, the slot conductors are in the side walls of the tubes outside the rotor body—as shown in Fig. 2—in a position where the metal is uninsulated. The gas flow therefore cannot be restricted by relative movement of the copper and the insulation.

The temperature rise of the stator is unaffected by the loss in the rotor windings, since all the heat absorbed by the hydrogen passing through the tubes is carried direct to the inlet to the gas coolers. In view of the greatly increased excitation loss permissible with direct cooling, this fact is of particular importance. The cooling surface of the conductors exposed to the gas is large, keeping the temperature difference between the copper and the hydrogen to a minimum. The chief factor affecting the mean temperature rise of the rotor windings is the temperature rise of the hydrogen as it passes through the conductor tubes. With the arrangement shown in Fig. 1 it is possible to equalise the volume of gas flowing through individual conductors. As the gas inlet temperature is also the same for all conductors, the ideal condition of uniform temperature from top to bottom of the slot is obtained. The design also avoids local concentration of mechanical stress in the rotor wedges or teeth such as arise with radial ducts discharging the gas into the gap.

With direct cooling as described above a considerable reduction can be made in frame sizes, and 3000 r.p.m. units with maximum outputs above 200MW are practicable.

Model Tests

Two complete rotor coils using full-size copper sections were assembled and subjected to exhaustive mechanical tests in the maker's works. A steel jig, about one-third the length of a 60MW rotor, was fabricated to support four rotor slots, and into these the two complete coils were wound using the specified conductors and insulation. Advantage was taken of the opportunity to develop a suitable winding technique prior to the manufacture of production machines. When the winding was completed the model was transferred to the G.E.C. Witton laboratories and a massive clamping arrangement (Fig. 4) was fitted to compress the conductors in the slots, so simulating the effects of centrifugal force. The load on the clamping bolts was measured by more than thirty-six individual strain gauges, so that complete control of the loading was possible. The windings were connected to a low-voltage heavy current d.c. supply and a suitable blower was erected to draw air through the conductor tubes.

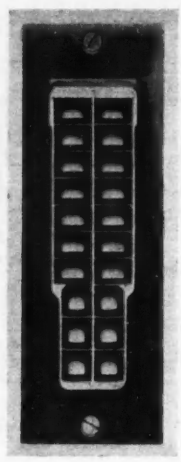


Fig. 3—Jig assembly, showing arrangement of the conductors and insulation in a rotor slot of a G.E.C. direct-cooled alternator

After preliminary tests had been made, automatically controlled thermal cycling was applied to the windings, the temperature of the copper first being raised rapidly to a value much above the operating conditions with no cooling on the model. Then the current was interrupted and the blower run to cool the copper as rapidly as possible, the temperature of the copper being checked along the length of selected bars by

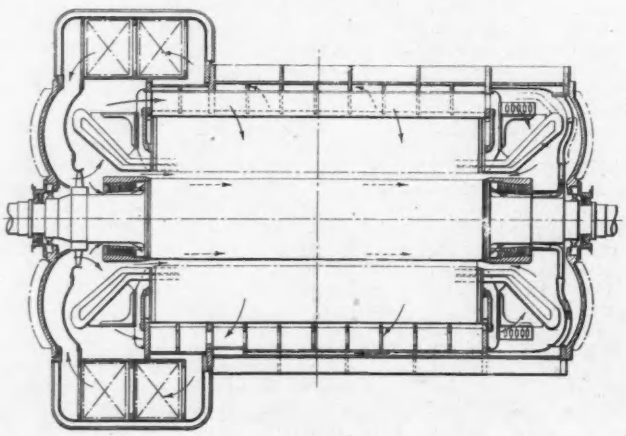


Fig. 1—Hydrogen gas flow through a G.E.C. direct-cooled alternator, showing the single-end entry and the two circuits for hydrogen flow

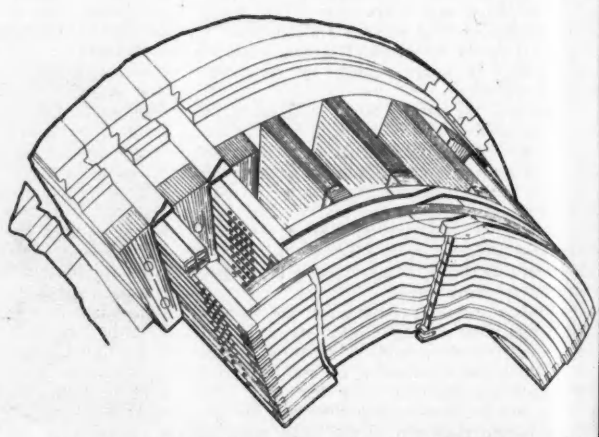


Fig. 2—End view of two rotor coils of a G.E.C. direct-cooled alternator, showing cross connections and gas ports in the conductors

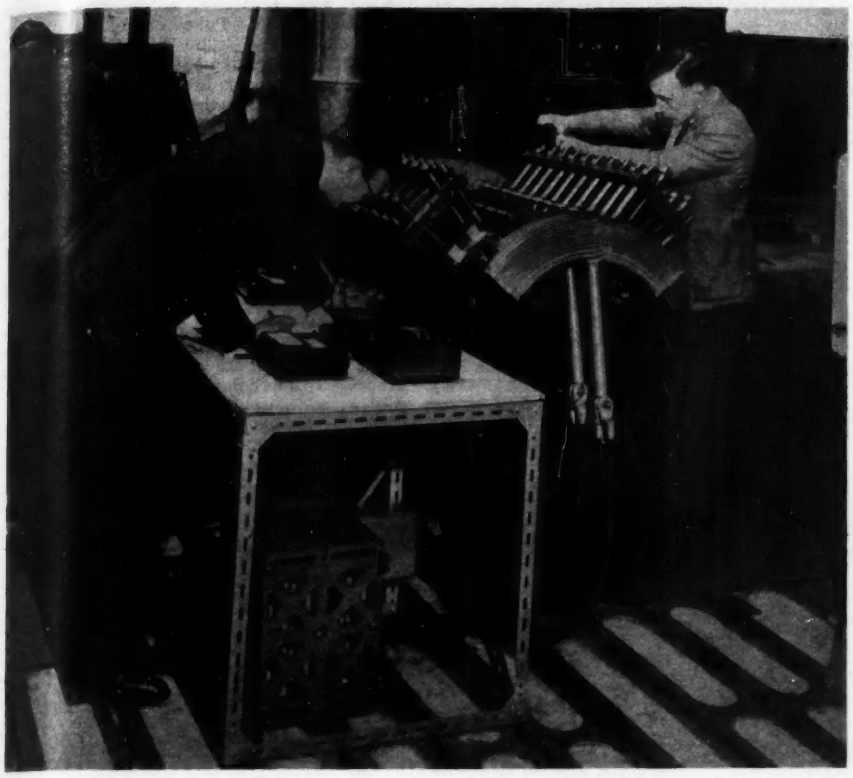


Fig. 4—Laboratory test rig of two rotor coils of a direct-cooled alternator

thermocouples built in as the winding proceeded and by means of voltage tappings on other bars; hence the resistance and mean temperature could be calculated (since in the model the end connectors were not ventilated they eventually reached a higher temperature than the tubes).

The duration of the thermal cycle is about fifteen minutes and since the test rig is running night and day, the time multiplier, compared with a full-size machine on two-shift operation, is of the order of 1 : 100. The thermal conditions are, of course, much more severe than in practice since in a power station full load excitation would not suddenly be switched on to an unloaded machine. Periodically, the insulation is examined for signs of deterioration, but up to the present none has been found. The tests are proceeding on a long-term basis and with higher temperatures to establish operating limits.

The reduction in frame size made possible by direct cooling of the rotor necessarily means increased loading of the stator. Tests on conventional alternators carrying overloads up to 33⅓ per cent, which correspond with the normal loadings proposed for direct-cooled machines, have demonstrated that stators of standard design will be entirely satisfactory.

Turbo-alternators embodying direct cooling, with outputs of 60MW and 120MW, are now in course of construction at the company's engineering works, Witton.

Museum of English Rural Life

On Wednesday of last week, we were present at the official opening of the Museum of English Rural Life, at Reading. The ceremony was performed by Sir Keith Murray, chairman of the University Grants Committee. The Chancellor of the University of Reading, Viscount Templewood, P.C., presided at the ceremony, and short speeches commending the work of the museum were made by Mr. J. F. Wolfenden, Vice-Chancellor of the University, and by Sir Leigh Ashton, president of the Museums Association. Work on the building up of this museum was started four years or so ago, the administration being vested in a committee of curators appointed by the Council of Reading University. From the beginning, Mr. J. W. Y. Higgs, who is the lecturer in agricultural history at the University, has served as Keeper of the Museum, which now has more than 3500 individual exhibits. The museum has now been permanently established at Whiteknights House, Reading, and its contents certainly present an interesting and informative picture of rural life in years past. Farming tools and implements and tools used by rural craftsmen inevitably occupy a prominent place and include items that cannot fail to interest engineers.

There are, for example, sixteen ploughs, representative of the craftsmanship of village ploughwrights in various parts of the country. One of them, produced about the middle of last century, is a Gloucestershire long plough, with a wooden mould board. Another interesting item among the tillage implements is a cup feed seed drill which is about 100 years old. Among the collection of threshing equipment there are flails, hand sieves and winnowers, a small hand-operated barn thresher, and a well-preserved example of a larger power-driven threshing machine, with side delivery, manufactured in the 1870s by Humphries of Pershore. The power for machines of this kind was, of course, provided by portable steam engines, some of which are still in use. The portable engine which has been presented to the museum was built by Clayton and Shuttleworth, of Lincoln, in 1876. It is illustrated herewith. It has a single cylinder and developed 7 or 8 h.p. The purchaser of the engine was provided with an instruction manual, and when the condition of rural highways in the 1870s is visualised, it is of interest to find that the manual states : " Moving the engine with water in the boiler or even with steam up may be done, provided the distance be not too great, say, one mile, and the road good, but do it only when circumstances compel you."

Portable steam engine, built by Clayton and Shuttleworth in 1877, for driving a threshing machine

Farm transport is illustrated in the museum by a variety of wagons and " tilt carts," and the collections of wheelwrights' and blacksmiths' tools recall the importance of those crafts in the maintenance of rural transport up till much less than a century ago ! Then there are examples of the equipment used in such essential farmhouse tasks as cheese making and brewing. Mechanical devices reminiscent of some aspects or rural life a century ago are the man-traps and spring guns displayed in the museum, alongside a couple of " flail-truncheons " used by gamekeepers in their encounters with poachers. The subject of our second illustration should be compared with the many modern fire-fighting appliances. It is the Banham (Norfolk) hand-operated " subscription " fire-engine, built in 1839 by Tilley, of Blackfriars Road, London. According to the museum's records, this appliance was still in use at the beginning of 1939.

" Subscription " fire engine for Banham, Norfolk, built in 1839 by Tilley, London'

There are two noteworthy facts about the work of this museum. The first is its well-equipped workshop in which every object is treated and as far as possible restored before being added to its appropriate collection. The second is the very full system of documentation that is being built up. It was decided from the beginning that a collection of exhibits such as that which has been assembled at Reading would lose much of its value without as detailed a record as possible. These records will undoubtedly prove increasingly useful to students of rural technological and social history.

Deepwell Pumping Attachment.—James Beresford and Son, Ltd., of Kitts Green, Birmingham, has introduced a "Hydro-ejector" attachment for use with the firm's "B20" and "B49" single-stage pumps. It is stated that with the aid of the attachment these pumps may now be used to raise up to 285 gallons of water per hour from wells as deep as 170ft.

Physical Society Exhibition

No. III—(*Concluded from page 603, April 29th*)

THE thirty-ninth annual exhibition organised by the Physical Society was held at the Royal Horticultural Society's New Hall, London, from April 25th to April 28th. Our description of the exhibits concludes with some further examples of engineering interest.

Mechanical Engineering Research Laboratory

Two methods of controlling shaft speeds accurately were demonstrated by the Mechanical Engineering Research Laboratory (D.S.I.R.), East Kilbride, Glasgow. These methods are being developed to control the speed of d.c. dynamometers of 200 to 350 h.p. to within 0·1 per cent of the desired speed.

Both methods make use of a disc on the dynamometer shaft to induce 60 impulses per revolution in an electromagnetic pick-up coil. In one method the frequency of these impulses is compared with that of a reference signal from a stable *R-C* oscillator monitored by a cold-cathode frequency meter. By phase-locking the impulses from the disc with the oscillator signal the shaft speed, in r.p.m., is tied to the oscillator frequency. In the second method a cold-cathode batching counter is set to the required speed in r.p.m. When the shaft speed is correct the counter produces one pulse per second and the required condition is checked by comparing the phase of this pulse with accurate one-second pulses from a quartz oscillator and a cold-cathode frequency divider.

A probe for measuring fluctuating fluid velocities at any point inside the volute of a centrifugal pump was also demonstrated. The probe consists of a cylinder 2cm long by 0·1cm diameter mounted on a spring which allows a small movement in the direction of flow only. The movement of the cylinder under flow conditions is applied to a mechanical-electrical transducer producing an output up to 20V. For a liquid of given density and for given dimensions of the cylinder the movement (which is proportional to the drag) is a function of C_d, the drag coefficient, and v^2, where v is the velocity of the liquid.

The cylinder demonstrated is for use in water (C_d between 0·95 and 1·2) with steady velocities between 3m and 30m per second at temperatures from 15 deg. to 45 deg. Cent.

National Physical Laboratory

An optical probe which has been developed for use with a new standard primary barometer, but has wider applications, was shown by the National Physical Laboratory (D.S.I.R.), Teddington, Middlesex. The purpose of the probe is to provide a means of assessing, from a distance, the position of an object which can be provided with a small reflecting plane surface. In operation, as the probe is traversed normally to the reflecting surface, an image of a special grating is passed over a replica grating and a light signal of varying intensity is produced photo-electrically and is indicated on a galvanometer scale. A unique maximum deflection is indicated when the tip of the probe is in the plane of the reflecting surface. Travel of the probe carriage is measured by reference to a linear standard using established methods. It is stated that the probe can be set reproducibly to within about ±0·001mm.

On the same stand two methods were demonstrated whereby the internal diameter of bores can be determined to within about ±0·00001in. One of these methods is based on the principle of auto-collimation, the diameter being determined by comparison with a reference standard built up from high-precision slip gauges and end plates. Bores with diameters ranging from 1·5in to 6in and depths up to 12in can be accommodated in the instrument, which is suitable for the measurement of a single diameter or several specified diameters.

When it is required to make a thorough investigation of variations in diameter throughout a bore use can be made of the second method of measurement. The instrument is pneumatic and is fitted with a self-locating measuring head which is easily manipulated within the bore, so that variations, both axially and in azimuth, can be observed. Bores of 2in to 6in diameter up to several feet long can be examined.

Philips Electrical, Ltd.

A new design of refrigerating machine that can be used for producing liquid air was shown by Philips Electrical, Ltd., Century House, Shaftesbury Avenue, London, W.C.2.

This machine operates on the Stirling cycle, which is reversible: instead of converting heat into mechanical energy (as is done in the Philips air engine) the machine is here driven by an electric motor and functions as a refrigerator. It is stated to be capable of reaching temperatures of −200 deg. Cent. rapidly and simply.

Very briefly, the installation consists of a liquefier with built-in air drier, carbon-dioxide remover and defroster mounted on a common bedplate with a 10 h.p. squirrel-cage motor, the drive being taken through a flexible uni-directional clutch. The control panel contains indicating gauges, hour meter and control gear. Safety devices close down the plant in the event of failure in the cooling system, pressure system or lubricating system.

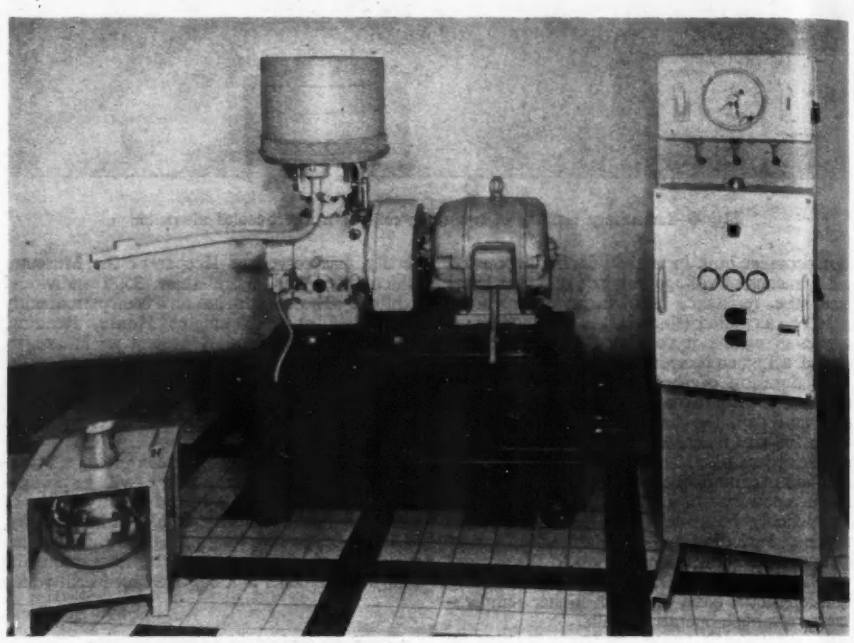


Fig. 11—Liquid air installation designed to attain a temperature of minus 200 deg. Cent.—Philips

The time required to reach low working temperatures is very short; liquid air can be produced within fifteen minutes of switching on. The plant will produce 5 litres of liquid air per hour at an ambient temperature of 20 deg. Cent. and will run continuously for sixteen hours in air at a relative humidity of 50 per cent. After this working period, defrosting of the air intake head is necessary, where moisture and carbon-dioxide have been deposited as ice and "snow," respectively. Defrosting takes up to one hour, including starting time for the next working cycle. The refrigerating capacity can be varied, both by changing the speed of rotation and by varying the gas pressure within the working space of the machine.

A. C. Cossor, Ltd.

An instrument for applying pulse techniques to the testing of active and passive networks (including, for example, cables) was shown by A. C. Cossor, Ltd., Cossor House, Highbury Grove, London, N.5.

This instrument consists of a milli-micro-second pulse generator, a display oscillograph and power packs. Pulses of about 100V peak amplitude and of substantially "$\sin^2$" form (the pulse width being adjustable to 5, 20 or 50 milli-microseconds) are generated in free-running blocking and shaping circuits. The oscillator also produces the saw-tooth voltage for the oscillograph time-base so that the transmitter pulse is always presented at the start of the cathode-ray-tube traverse and is automatically locked.

If a passive network, such as a cable (from about 18in to 200 yards long) is connected to the pulse source then any mismatch that may exist will be detectable by the appearance of echoes of the transmitter pulse on the c.r.t. trace.

Information about the cable (for example, the position and magnitude of any discontinuity) can be deduced from the position and size of the echoes. This technique can be applied to transmission cables and delay cables. If both ends of the line are available the characteristics of the transmitted pulse, as seen at the far end of the network, can, if required, be examined.

J. Langham Thompson, Ltd.

A high-speed camera (which has been developed from the original work of Dr. J. S. Courtney-Pratt* in the Physics Department of Cambridge University and is now being made under licence from the National Research Development Council) was shown by J. Langham Thompson, Ltd., Bushey Heath, Herts. This camera enables a series of photographs to be taken at high speed. Two hundred shots can be taken in sequence at rates up to 100,000 per second.

An assembly of small lenses embossed in a plastics material and bonded to a glass plate is used to dissect the picture into a large number of small elements; each set of picture elements is recorded simultaneously on the photographic plate with a spacing between adjacent elements that is large compared with the size of each element. The displacement of the picture element is produced by altering the direction in which light falls upon the assembly of small lenses, this effect being achieved by using a Nipkow disc.

The complete series of pictures is recorded on an ordinary photographic plate and after processing, the plate is replaced in the film carrier to examine the high-speed phenomena at slow speed, or to take individual pictures of interesting characteristics. After replacing the photographic plate in the holder, a bright light source is introduced into the main camera lens which produces silhouette pictures on a ground glass

* Fast Multiple Frame Photography, *Journal of Photographic Science*, Vol. 1, 21, 1953.

screen situated at the rear of the film carrier. This process may be reversed when convenient, and the event displayed on a screen situated in the position that the object adopted whilst being photographed.

The rotation of the Nipkow disc will show on the ground glass screen the series of photographs that was recorded at high speed. The aperture disc may be stopped in any desired angular position and simple contact prints taken of the event in its various stages of development. In this way the completed record is " unscrambled " for analysis.

The camera is 12in high by 18in long by 9in wide and weighs 47 lb. The main camera lens is a 2in, f/2·9 Dallmayer " Pentac " arranged with the Nipkow disc revolving between the main components of the lens. Because of the concentration of light produced by each lenticular element of the plate the photographic brightness is high. With the lenticular plates used in the series " C600 " camera the overall effective aperture is f/6·3.

45/75 H.P. Gas Turbine

THE " Mars " gas turbine, which is made in America by the Solar Aircraft Company of San Diego, was recently demonstrated in London. Its manufacture in this country has now been arranged by William Sugg and Co., Ltd., of Westminster, a subsidiary company, Sugg Solar, Ltd., having been formed which will manufacture the gas turbine under licence for both military and industrial uses at Crawley, Sussex. The new company will have licence rights in the U.K., Europe and the Commonwealth countries with the exception of Canada. The licence covers all present applications of the " Mars " engine, other applications now being developed and any future developments. The " Mars " is already in service as a fire-fighting pump, as an airborne generator set and as a ground power unit for starting jet engines, and has also been ordered as a prime mover for various applications by the U.S. Army Corps of Engineers and the U.S. Navy. The engine is regarded as a suitable power source for electronic equipment, for providing compressed air, powering of small boats, land vehicles, air blowers and space heaters.

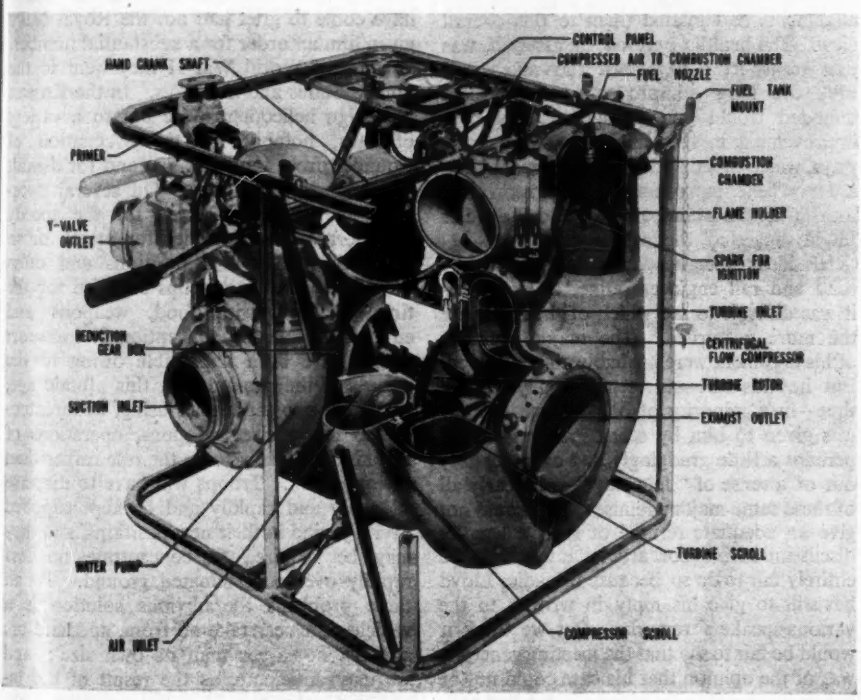
The " Mars " gas turbine is a small, portable plant developing 40/75 h.p., depending on conditions and requirements of its application. It operates at a speed of approximately 40,000 r.p.m. on natural gas, or any distillate fuel such as paraffin or petrol. The basic engine, including speed-reducing gears, weighs less than 100 lb and is smaller than a 2ft cube. It has a centrifugal compressor and a radial inward-flow turbine mounted back to back. It may be started by hand or electrically. The best fuel consumption is 1·15 lb per brake horsepower per hour.

The " Mars " engine was designed for lightness, compact simplicity and easy starting in service conditions. Its construction is such that even major overhaul, occurring at intervals of 750 hours of fully rated service, usually involves merely changing the sheet-metal combustion chamber, some of the accessories and, by way of caution, the two main rotary bearing assemblies.

Both the fire pump and the airborne generator applications were demonstrated. The pump, illustrated below, delivers 415 Imperial gallons per minute at a pressure of 100 lb per square inch with a 16ft suction lift, and the total weight is only 175 lb.

The fire-fighting unit has been ordered by the U.S. Bureau of Ships for fighting ship fires and a contract has been received from the U.S. Navy which requires the company to be in preparation for production for thousands of the turbine-pump units.

This unit was first described in THE ENGINEER, January 25, 1952, and detailed references were given in the issue February 12, 1954. In THE ENGINEER, January 28, 1955, an account was given of the utilisation and reliability of the aeronautical application of this unit in America.

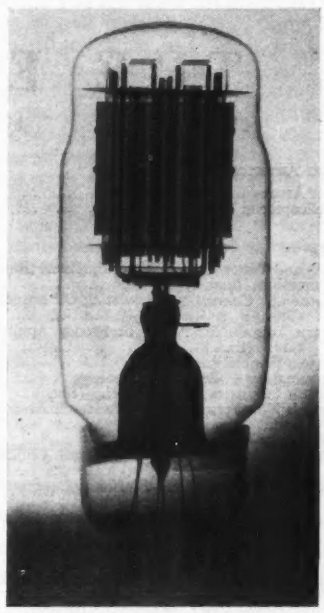


45-75 h.p. gas-turbo fire pump

Beam Tetrode for Audio Frequency Amplification

A NEW valve, the " Osram " KT55 beam tetrode, which is designed primarily for use as an audio frequency amplifier in d.c./a.c. equipment using a series-connected heater chain, has been introduced by The General Electric Company, Ltd. Two of these valves used as pentodes in push-pull are stated to be capable of an output of 25W from a d.c. mains supply of 220V (about double that hitherto obtainable from valves in this class). The KT55 valve can also be used in voltage stabilisers and as a source of power for running a.c. gramophone and similar equipment off d.c. mains.

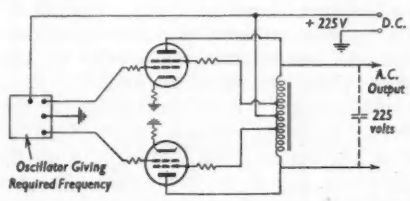
It is an Octal-based valve, with a maximum overall length of 14·3cm and a maximum diameter of 5·2cm ; the heater rating is 0·3A, 52V, and the maximum anode dissipation is 25W. As a pentode, the valve attains a " slope " value of 16 mA/volt, and as a triode the valve has the unusually low anode resistance of 410 ohms. An X-ray view of the valve is reproduced herewith.



The general construction including the twin cathodes can be seen in this X-ray view of the " Osram " KT55 beam tetrode

In a recommended amplifier circuit two KT55 valves are used in conjunction with the " Osram " low-noise pentode Z729, and a triode such as the L63 valve. Such an amplifier circuit has a high sensitivity and in " ultra-linear " operation an output of 22W with a distortion of only 1·5 per cent can be obtained from a 55mV input, which is increased to 300mV by the application of degeneration.

When unusually low d.c supply voltages are found, as, for example, in marine applications, the KT55 valve is particularly suitable. It can be used in conjunction with a " 305 " barretter for supply voltages from 150V to 200V and with a suitable resistor for voltages from 125V to 150V.



A circuit using two KT55 valves to operate an a.c. three-speed gramophone motor from d.c. mains

Below 125V two chains are recommended, the two KT55 valves being connected in series in one chain with a small resistor, if necessary, and a barretter, the remaining valves being incorporated in the second chain.

For low a.c. voltages an auto-transformer may be used for the anode supply with the heaters connected as for a d.c. supply. An alternative method of supplying anode voltage with low-voltage a.c. supply makes use of a voltage doubler circuit which gives a d.c. line voltage of 220V from 110V a.c.

The KT55 valve has proved useful for modifying a.c. equipment so that it can be operated from d.c. mains, or non-standard a.c. frequencies, for the valve can be used as a power generator in cases where a low-power a.c. motor is required to be driven from a d.c. mains supply. Thus an a.c. three-speed gramophone motor can readily be made to operate from d.c. mains by using it in conjunction with a circuit such as that shown above.

THE ENGINEER

Vol. 199 MAY 6, 1955 No. 5180

LEADING ARTICLES—

Cat Among the Pigeons 634
Helicopter in Nuclear War... 634

ARTICLES—

Air- and Water-Cooled Diesel Engines. (Illus.) 643
Aluminium Hatch Board 645
Automatic Control of Modulating Oil Burners. (Illus.) 639
Beam Tetrode for Audio Frequency Application. (Illus.)... 633
Beama Annual Report 617
Birmingham College of Technology 617
British Industries Fair. No. II. (Illus.)... ... 620
British Non-Ferrous Metals Research Association... 617
Chemistry Research in 1954 637
Coal Preparation Plant at Lynemouth Colliery. (Illus.) 624
Concrete Batching and Finishing Equipment. (Illus.) 642
Direct Cooling of Turbo-Alternator Rotors. (Illus.) 630
Discharge of Gas from Cylinder to Atmosphere. No. III. (Illus.) 618
Engineering Building at Sheffield University. (Illus.) 641
Experimental Rail Containers. (Illus.) 645
Institute of Fuel 617
Institution of Naval Architects. No. V 638
International Conference on Fatigue of Metals... 617
Iron and Steel Institute. No. I... 622
Loch Glashan Hydro-Electric Scheme in Argyllshire 642
Museum of English Rural Life. (Illus.) 631
Oil-Fired Geared Steam Shunting Locomotive. (Illus.) 628
Opening of New Engineering Building at Sheffield University. (Illus.) 617
Physical Society Exhibition. No. III. (Illus.) 632
Transport Helicopter. No. I. (Illus.) 636
V.H.F. Broadcast Transmitting Station at Wrotham. (Illus.) 626
45/75 H.P. Gas Turbine. (Illus.) 633
1700 B.H.P. Diesel Locomotive for Switzerland. (Illus.) 642

AMERICAN SECTION—

Test of Corrugated Steel Pipe Culvert at Cullman, Alabama. (Illus.) 646
8000-Ton Hydraulic Extrusion Press. (Illus.)... 648
Ground Power Unit for Starting Jet Aircraft. (Illus.) 648

LITERATURE 635
Books Received 636
Short Notices 636

OBITUARY—

Major S. J. Thompson, D.S.O. 635

NEWS AND NOTES—

British Patent Specifications. (Illus.) 651
British Standards Institution 652
Forthcoming Engagements... 652
Industrial and Labour Notes 649
Launches and Trial Trips 652
Personal and Business 650

CAT AMONG THE PIGEONS

Cheer leaders would not have an easy task if they wished to enliven a meeting of the Institution of Civil Engineers, however provocative its topic happened to be. The Institution's meetings proceed with a quiet dignity which the excesses of the importunate world outside fail to influence in any degree at all. So it should be, for in such an atmosphere thorny problems can be calmly and deliberately unravelled and the "vast sources of power in Nature" more readily comprehended and made to serve man's needs. In such surroundings an intense feeling can be expressed, merely by lifting the hand, and a raised voice is an excess—an overstatement—seldom, if ever, indulged in. The unruffled urbanity of our senior institution ran true to form on Tuesday of last week, when the paper by Brigadier T. I. Lloyd entitled "The Potentialities of the British Railways' System as a Reserved Roadway System" was discussed. Only by inferences, such as the slight sense of apprehension in the audience, and the attendance of a veritable platoon of well-briefed speakers from the British Transport Commission, could we appreciate how radical the subject of the meeting really was. To stray so far from the well-defined paths of conventional technical thought was at times an uneasy experience, both for speakers and audience alike. Certainly, the paper provoked a great deal of interest and the discussion ranged over many subjects. Some novel views were expressed, too, during the evening; it was suggested that roads should be built over railways, that railways in cities should be put into tunnels, and so on. We do not recall anyone suggesting that roads should be turned into railways!

Briefly, Brigadier Lloyd's case was that a great improvement in transport could be effected by an amalgam of road and rail services as we now know them. If the permanent way of the railways were converted into a road surface, he postulated, and traffic upon it (forty-seater buses or bus and trailer combinations for passenger and 20-ton lorries for freight, all averaging about 60 m.p.h.), was operated to professional standards, the resulting system would have an overall capacity "so vast that not even British Railways' recapture of much of the present roadborne traffic would be likely to result in loading the system to more than a small percentage of its capacity." Evidence to show that such a transformation would result in a better service at less cost was given in some detail in the paper. Brigadier Lloyd considered such factors as gradients and alignments and related them to this overall view. The healthy outlook, he asserted, was that transport always cost too much and took too long; improvements at present intended would give perhaps 15 per cent improvement in the efficiency of the railways, which met one-fifth of the demand, and a 1 per cent improvement in the remaining four-fifths. In a competitive world, Brigadier Lloyd suggested, that was not enough.

His ideas were heavily criticised, both by road and rail engineers alike, and at times it was difficult to see which of the two were the more perturbed. The major premises of his argument were probably all challenged. But he was not—as seemed likely at one time—in a minority of one. Some support was given to him by other speakers—albeit perhaps a little grudgingly and even possibly out of a sense of "fair play"—on nearly all of these same major premises. We could not give an adequate résumé of such a lengthy discussion in this short article. It would not be entirely fair to do so, because Brigadier Lloyd has still to give his reply, in writing, to the various speakers' remarks. But we think it would be fair to say that the meeting generally was of the opinion that his case could not be properly assessed without more detailed consideration; it was very far from proved. Perhaps the major flaw in this idea of transforming railways into reserved roadways was the assumption that dual carriageways would not be essential, and that narrower formation widths than those required by most motorway designs would be satisfactory. The Ministry of Transport has in fact lent support to a single carriageway construction; but this is generally understood to be a decision of expediency, to provide a route before the second carriageway is built. Several speakers blanched (metaphorically) at the thought of forty-seater buses travelling at over 60 m.p.h. on a single 22ft two-way road! Even if a wider formation were needed, however, it does not rule out the feasibility of the transformation, but makes it more costly; and cheapness is at the root of the argument. Dr. Glanville summed up the paper in a way which would probably have the widest support. He pointed out that railway speed and efficiency needed to be revolutionised, and the paper suggested one way of doing that. But the cost figures given were, he thought, very optimistic and the paper did not prove that time and money would be saved. The suggestion would be needed to be gone into thoroughly to find out whether or not it would be advantageous. Perhaps we might add that the existence of even one complete motorway route, in operation in this country, would do a great deal to settle this argument, as well as many other contentious points of view about motorways generally. In fact, the argument at the "Civils" should not be allowed to obscure the urgent national need for adequate trunk roads.

THE HELICOPTER IN NUCLEAR WAR

In view of the increasing attention now being paid to the value of the helicopter, both for civil and military purposes, particularly in the United States, it is pleasing to record that the Royal Navy has had no small share in its development. Sikorsky's plans for making these machines in America would have come to grief had not the Royal Navy given him an order for a substantial number. Because of World War II they went to the United States and not to us. In the Korean campaign helicopters were put to a variety of uses, notably for the evacuation of wounded from the front line and for assault and support operations. On several occasions they were employed for the speedy transport of troops either for attack or to reinforce weakly held positions and often they kept front line troops supplied for the time required, with food, weapons and equipment, when conventional transport would have been impossible owing to the nature of the ground. In this atomic age, with the opposing armies using, or threatening to use nuclear weapons, operations of this kind are likely to be the rule rather than the exception. Troops will have to disperse suddenly and rapidly and be kept supplied over a period in their new positions, and they may be required to concentrate no less rapidly over contaminated ground. To all these problems the obvious solution is a vehicle which can take off from, and land on, an area no larger than its own size; and we may anticipate, as the result of the investigations of the Joint Experimental Helicopter Unit, a demand for a substantial

addition to the forty-two helicopters now available for duty with the Army. Moreover, if the Navy is—in the words of the Defence White Paper—to "contribute to the Allied striking fleet . . . to hit the enemy either independently or in support of Allied land forces and land-based forces," helicopters will be required in large numbers in amphibious warfare. Atomic missiles and other new weapons likely to be employed by the defenders rule out the practicability of the kind of amphibious operation carried out so successfully by the Americans in World War II, with assault craft racing to the beaches. But the need still remains for landing speedily a large number of troops and a great deal of equipment on an unorganised beach.

It thus seems regrettable that the Admiralty, which has had a very progressive outlook in ordering a substantial number of helicopters for experimental anti-submarine work, should not have been able to spare any of these machines for the training of Royal Marine Commandos, either at home or in the Mediterranean. Extensive amphibious warfare exercises have been carried out by United States Marines, in which helicopters replaced the landing craft, and it is interesting to note that the United States Navy's current building and conversion programme provides for the conversion of a vessel into an assault helicopter transport. Virtually any large ship can be adapted for this purpose as the take-off area required is only a matter of about 30 square feet. In the exercises carried out by United States Marines, the ships carrying the helicopters were dispersed over a wide area and remained some 30 to 50 miles off shore, well outside the range of the shore batteries. It was found possible to land an invading force across 40 miles of water in about the same time as it takes a landing craft to cover 8000 yards. With carrier-borne aircraft providing air supremacy the helicopter assault force, having no tide or underwater obstacles to deal with, was landed well inshore in a more defensible position, the helicopters returning, as required, with more guns, ammunition and supplies and to evacuate wounded.

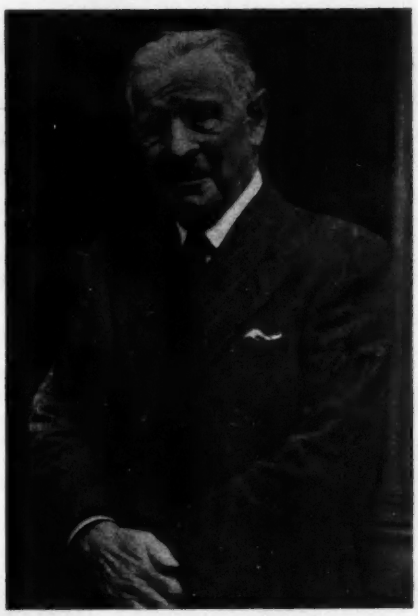
In this country we are developing the gear-driven helicopter to provide single and multi-engined machines. The "Bristol 173," the first twin-engined, twin-rotor helicopter in the world to go into production, was the result of this development and 100 of these machines have been ordered for the Fighting Services, mainly for the Navy for anti-submarine work. It is the intention later to develop helicopters with gas turbine engines. The Americans have also designed twin-rotor machines, one—the "Bell XSHL-1" being the first helicopter to be specifically designed for anti-submarine operations. They are fitted with search radar, sonobuoys and a formidable anti-submarine armament, but it seems probable that pending further developments the helicopter will be used primarily for the detection of submarines, working in conjunction with fixed wing aircraft and surface forces. An asdic installation lowered into the sea from a hovering helicopter detects a submarine in the same way as when it is installed in a surface ship. The helicopter then passes the information to ships or aircraft in the vicinity. The practicability of operating these machines from merchant ships has been investigated and trials have shown that they can take off and land on successfully in moderate weather. In their present state of development, however, there would be difficulty, when operating from merchant ships, in deploying them economically and giving them adequate maintenance. None the less, there is no doubt whatever that the helicopter is destined to play an increasingly important role both in sea and land warfare. Its main limitations at present are lack of range and speed, the average helicopters in use to-day having a range of about 400 miles and a cruising speed of under 100 miles an hour.

Obituary

MAJOR S. J. THOMPSON, D.S.O.

We regret to have to record the death of Major Stephen John Thompson, of Stanley Hall, Bridgnorth, Shropshire, which occurred on Saturday last, April 30th. Major Thompson, who was in his eightieth year, had been associated with the family engineering firm, John Thompson, Ltd., of Wolverhampton, for more than sixty years. He retired from the office of governing director about a year ago.

Stephen Thompson received his general education at Wolverhampton Grammar School, and his training as an engineer in the firm founded by his grandfather. He himself recalled on one occasion that his family had been engaged in boilermaking for four generations, and that his grandfather had begun boilermaking in Staffordshire in 1820. The whole of Major Thompson's professional career was devoted to the service and development of the business which bears his name. He was away from it, on active service with the Royal Artillery, during the first world war and was awarded the D.S.O. in 1916. For nearly fifty years Major Thompson took an active part in the affairs of the Territorial Army, and during the second world war was an honorary colonel of the 119 Field Regiment, R.A. For nearly thirty years he served on the governing board of the Royal Wolverhampton School, and was a deputy lieutenant and former High Sheriff of the County of Staffordshire.



Stephen John Thompson

Major Thompson also gave many years of service to the work of the Institution of Mechanical Engineers. He was elected to membership of the Institution in 1902, was among those who took a prominent part in the formation of the Midland branch in 1921, and, following a period of service on the council, became president of the Institution in 1942. Despite the many demands upon the engineering industry created by the war, Major Thompson gave unstintingly of his time to his presidential duties. His presidential address, delivered in October, 1942, was appropriately entitled "Boilers —Past and Present." It was a valuable historical survey, with special emphasis on the progress made during the fifty years in which Major Thompson had then been engaged in the business of boilermaking.

Literature

An Introduction to Cost Accountancy. Volume III. By R. Warwick Dobson. London: Gee and Co. (Publishers), Ltd., 27, Basinghall Street, E.C.2. Price 37s. 6d.

After a cursory glance through this, the third volume of a comprehensive study of cost accountancy in its various phases, an engineer would probably be appalled by the large number of specimen forms depicted, and decide in his own mind that a system involving so much paper work could not be justified. Actually, however, a number of forms are intended to serve the same purpose and are illustrated to show the different methods of attempting to reach the same end. The author rightly points out that the greater the number of forms the greater are the chances of error, and for this reason alone it is essential to keep the number as low as is consistent with efficiency. At the same time if accurate results are to be obtained a considerable amount of clerical work must be expected, but much can be done to eliminate unnecessary information, and, what is most important, to avoid duplication. Suggestions are made by Mr. Dobson as to where short cuts can safely be taken.

The ground covered by this work is cost recording and presentation, which to a certain extent is an amplification of what has been touched upon in the preceding volumes. Each chapter deals with a distinct aspect of the subject, and the first considers accounting for sales, followed by other chapters on accounting for materials, for wages, for expense, for a firm's fixed assets, for cost centres, for cost units, for standard costs and marginal costs. The concluding chapter is occupied with uniform costing, and the very definite advantages attaching to it. Each chapter clearly sets out the basic records that are considered to be essential, with an explanation of the book-keeping involved and the method of presentation of the information concerning the particular aspect that has been dealt with in the chapter. The many distinct systems adopted by industry to obtain the necessary results are illustrated by copies of a variety of forms that are in current use. Incidentally, the printing on some of the forms reproduced is so very small that it is necessary to use a magnifying glass before the headings can be read. In some cases it is difficult to link up the illustrations with the relevant text, although by means of the tabular statements that are provided the information obtained by the different systems can be compared.

The value of uniform cost accounting is

stressed, and by uniform costing is meant the practice of using.the same system of accounting by several undertakings, the same forms, the same methods and organisation, the same routine, and the same wages and expense classifications, and as far as possible the same personal cost centres, but in this case it is unusual to find the organisation of two factories to be identical. The advantages of a uniform cost accounting are easily realised, for among other things may be mentioned the fact that consolidated statements can more readily be prepared, comparisons of costs are easily made, training of staff is simplified, while office appliances can be transferred from factory to factory as required. This is certainly a subject that warrants further attention by industrialists to their mutual advantage.

The relative costs of different methods is a point of importance that has not been broached, indeed we should welcome an expression of opinion, say as to the cost of using the Kalamazoo system of recording compared with that of the Hollerith, to mention two that have their forms fairly fully illustrated. It is understood that while some of the accounting machines can be hired they cannot be purchased ; what has Mr. Dobson to say as to this ?

The three volumes taken together give the reader a detailed exposition of a very important subject, and the author is justified in claiming that his work is fuller than any previously published in this country, and for this reason we feel he has been unduly modest in the choice of a title in that it goes far beyond the rudiments, and contains much that should prove useful and suggestive to the cost accountant of many years' standing. The average engineer may probably be content with acquiring a " nodding acquaintance" with this branch of the organisation and will be satisfied with that which is covered in the first volume, as his main desire, undoubtedly, will be to examine and act upon the data presented to him by the cost department, but those who desire to delve more deeply into the matter will welcome this third volume which certainly will widen their perspective.

Throughout his whole treatise the author has evidenced a spirit of impartiality which disarms criticism, indeed, he may have been wise to leave it to his reader to draw his own conclusions.

SHORT NOTICE

Modern Fluorescent Lighting. By A. D. S. Atkinson, A.M.I.E.E., F.I.E.S. London: George Newnes, Ltd., Tower House, Southampton Street, Strand, W.C.2. Price 15s.—A good deal of progress has been made in fluorescent lighting practice since 1951, when this book was first published ; and in the preparation of the second edition, the subject matter has been brought up to date. For example, the information on filament lamp ballasts has been revised and newly tabulated material concerning lumen output has been included in the lamp data tables. The appendix (VI) dealing with coloured fluorescent lamps has been rewritten and a new appendix on " Preferred Colour of Light " has been added to serve as a guide in the choosing of the colour of light best suited to illuminate various kinds of merchandise.

BOOKS RECEIVED

Protective Current Transformers and Circuits. By P. Mathews. London : Chapman and Hall, Ltd., 37, Essex Street, Strand, W.C.2. Price 36s.

Conveyors and Related Equipment. Third edition. By W. G. Hudson. London : Chapman and Hall, Ltd., 37, Essex Street, Strand, W.C.2. Price 72s.

Spontaneous Ignition of Liquid Fuels. By B. P. Mullins. London : Butterworths Scientific Publications, Ltd., 88, Kingsway, W.C.2. Price 20s.

Ship and Boat Builder : Annual Review, 1955. Compiled by the editorial staff of *Ship and Boat Builder*. London : John Trundell (Publishers), Ltd., Temple Chambers, Temple Avenue, E.C.4. Price 30s.

The Transport Helicopter

By Dr. IGOR I. SIKORSKY, Mem.A.S.M.E.*

No. I

Abstracts from this James Clayton lecture, which was read by the author on April 29th, before the Institution of Mechanical Engineers, include a brief history of the helicopter and a review of present and future developments of this craft. Dr. Sikorsky particularly stresses the use of the helicopter using externally slung loads, and states his belief that the single mechanically driven rotor will dominate helicopter configurations for a long time.

THE helicopter requires neither a prepared space for departure and arrival, nor a road to follow. It is free from both. It approaches closer than any other vehicle to the fulfilment of the ancient dreams of mankind which were woven around a flying horse, the magic carpet, and the like.

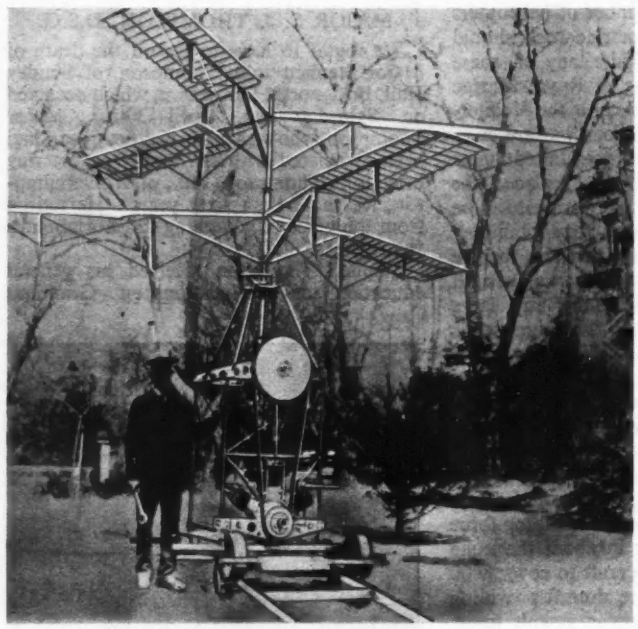


Fig. 1—Sikorsky Helicopter, 1910

Practically every vehicle used by man is limited with respect to the load it carries, not only as regards weight but also with respect to the size or bulk of the object to be transported. Such is the case with the railroad, truck, or airplane. Indirectly, this is equally true with respect to the steamship because, as a rule, any object or cargo must be delivered to and from the ship. Such limitation does not exist where the helicopter is concerned. Here only the weight limitation must be observed but not the length or bulk of the objects to be carried. This feature is of tremendous importance and has already been extensively applied by military as well as by commercial operators of helicopters.

The loading and unloading of a train, truck, or airplane, as a rule, require personnel and equipment available for the work. The helicopter, on the other hand, can pick up virtually any of its cargo and deliver it exactly at the destination point. It can, if necessary, complete both the pick-up and the delivery without alighting. This faculty, combined with the previous ones, expands the sphere of usefulness of the helicopter beyond anything which we can visualise at present. Indeed, it will really become valuable when aircraft of considerable lifting capacity become available, which can definitely be expected in the very near future.

* Engineering Manager, Sikorsky Aircraft Division, The United Aircraft Corporation, Hartford, Connecticut.

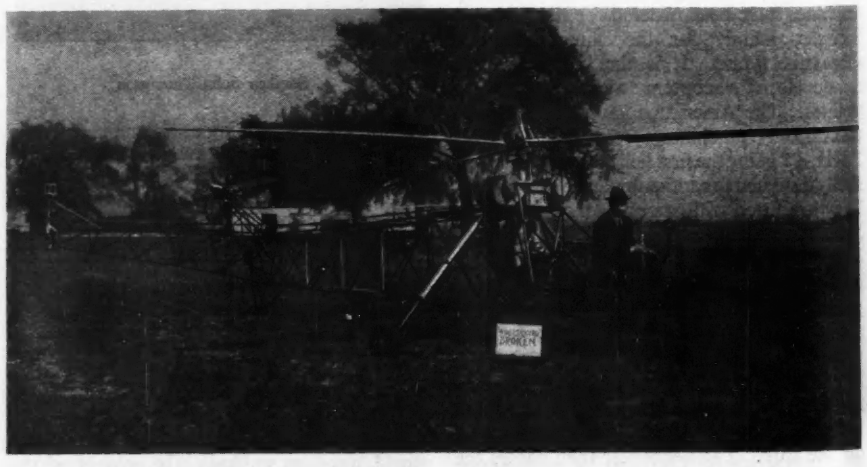


Fig. 2—The Sikorsky " VS-300 " with three control rotors, piloted by the designer

Fig. 3—The ability of a helicopter to carry huge, bulky objects on the outside was extensively utilised by several operators. This photograph shows the "S-55" carrying another complete craft

History

The idea of the helicopter is very old, and probably antedates those of the airplane or even the balloon. Over 400 years ago Leonardo da Vinci made sketches of a man-carrying helicopter.

In France, around 1784, Launoy and Bienvenue made a flying model of a helicopter. In England, around the middle of the nineteenth century, the famous student of flying, Sir George Cayley (1773–1857), produced a project and made a model of a power-driven man-carrying helicopter.

During the latter half of the nineteenth century several other projects were made and interesting flying models demonstrated. In 1907 Louis Breguet was apparently the first man to take off in a helicopter. Between the 1914–18 and 1939–45 wars, the autogyro was created by Juan de la Cierva, in Spain, and several helicopters were produced in different countries with gradually increasing degrees of success until, around 1937, Dr. Heinrich Focke produced what was probably the first practical helicopter. It was capable of rising to an altitude of several thousand feet, flying from town to town, making auto-rotative landings, and demonstrating full control in flight.

In 1909 I began work in aviation by designing and constructing a helicopter with a motor of 25 h.p. (Fig. 1). This motor, the best available at that time, proved inadequate.

In 1939 in Stratford, Connecticut, the American "VS-300" (Fig. 2) made its first flights. This was the world's first successful single-main-rotor helicopter and led, in 1943, to the "R4," which, at Bridgeport, Connecticut, became history's first production helicopter.

During the 1939–45 war these helicopters were used for the first time in actual operation for liaison and rescue missions. Later, several commercial airlines inaugurated services with somewhat larger helicopters of similar general design.

It may be considered that the helicopter reached its maturity during the Korean conflict (Fig. 3). Korea has been rightfully called "the proving ground of the helicopter." Helicopters moved in with the first United Nations' troops in June, 1950. They delivered replacements, food, medical supplies, and ammunition to the battle lines. They laid communication wires. It is recorded that Army engineers flew a bridge into position one piece at a time so that troops could move up into new territory. On another occasion "S-55's" flew 34,000 lb of supplies to infantrymen who were temporarily isolated. Thus, in the short period of a few weeks, what had been military theory, in so far as helicopter operations were concerned, became military fact.

It became the chief means of travel for battle commanders and enabled them to visit, inspect and supervise even the front-line positions to an extent never before possible. Carrying of men and materials assumed substantial proportions. For instance, a marine helicopter transport squadron of the First Marine Aircraft Wing in Korea, in 558 hours of flight time, carried almost 1,700,000 lb of cargo. This undertaking was a five-day effort to keep two regiments of Marines completely supplied by helicopter.

The records of a single service, Air Rescue, have the names of 9500 men who owe their lives to the helicopter. To this number must be added the rescues accomplished by the Navy, with the "S-58" the Army and Marine Corps. Conservative reports have set the total number of helicopter evacuees at nearly 20,000. Of this number about 1500 men were rescued from behind enemy lines.

Present Status

The present status of the art may be illustrated by the following brief record of facts and figures.

The official world record for speed is 156·005 m.p.h., reached in 1954. The official world's helicopter altitude record of 24,500ft was established at Bridgeport on October 17, 1954. Both these records were achieved by the American "S-59" Army helicopter powered by a 400 h.p. Artouste "Turbomeca" turbine (Fig. 4).

The longest helicopter non-stop flight, 1234 miles, was completed by test pilot Elton J. Smith, piloting a "47-D1" Bell helicopter, powered by a 200 h.p. Franklin engine, which flew from Fort Worth, Texas, to Niagara Falls, New York, on September 17, 1952.

The heaviest useful load carried was well in excess of 10,000 lb lifted in the course of a routine engineering test by the American "S-56" marine assault helicopter powered by two Pratt and Whitney "R-2800" engines. This flight, with chief pilot D. Viner at the controls, took place in January, 1955.

One of the most significant long-distance flights was the crossing of the Atlantic by two helicopters of the Air Rescue Service in the summer of 1952. The helicoptors used were two American "S-55's," powered by Pratt and Whitney 600 h.p. "Wasp" engines.

(To be concluded)

Fig. 4—Sikorsky "S-59," the first Sikorsky turbine-powered helicopter, built for the U.S. Army, reached a speed of 156·005 m.p.h. in 1954, the official world speed record, and achieved the helicopter altitude record of 24,500ft

Chemistry Research in 1954

Last week the Chemical Research Laboratory's annual report, dealing with activities during 1954, was published by H.M. Stationery Office. In addition to research, these included the provision to industry of four standard organic compounds, bacterial cultures, and pure metals. The laboratory's advisory services were again in great demand and inquiries centred largely on problems of corrosion, but assistance was also given in the fields of infra-red spectroscopy, organic techniques, osmometry, radio-chemistry and microbiology. In the field of corrosion research, the report says that work is being undertaken to correlate such variables as rate of movement, temperature and composition of the solution. A survey is being made of substances allied to benzoic acid to determine their value as corrosion inhibitors. By an electrical method, the continuity of protective coatings inside water mains has been determined. A further site where ancient iron objects were found buried in virtually uncorroded condition has been investigated, in co-operation with archæologists, and the effect is ascribed to inhibition of bacteria by tannic acid; field investigations with tannins are reported. Points from other fields of research include quantitative separations of copper, cobalt, nickel and iron and also of other metals by ion-exchange techniques, and recommendations have been made regarding the recovery of selenium from pyrites.

Institution of Naval Architects

ANNUAL SPRING MEETING

No. V—(*Continued from page 589, April 29th*)

THE last paper on Tuesday, April 5th, was presented before a joint meeting of the Institution and the Institute of Marine Engineers. The paper was :—

SEA TRIALS ON A 9500-TON DEADWEIGHT MOTOR CARGO LINER

By Professor G. Aertssen

Summary

As the second part of the programme of sea trials of the Centre Belge de Recherches Navals, M.V. " Lubumbashi," a cargo liner of the Compagnie Maritime Belge, was equipped with torsionmeter, thrustmeter, pitometer log, anemometer and wind-vane. In varying conditions of draught, fouling and weather, numerous records were collected related to speed through the water, power, fuel consumption, thrust revolutions, ship motions, wind and waves. The service data are analysed in a similar manner to that of the victory ship " Tervaete," and an attempt is made to ascertain the efficiency and economy of the ship and machinery in different service conditions. A predominant part of the programme was the ship-model correlation, two measured mile trials being carried out. The first was part of the official trials of the ship in ballast condition and in the second the ship was in the loaded condition at the beginning of her maiden voyage.

Discussion

Dr. J. F. Allan : This paper has a lot of points of contact with the work which has been going on in this country by the British Shipbuilding Research Association and the National Physical Laboratory. On the question of accuracy, the measurement of the speed through the water is dependent on the pitometer log and that is calibrated on the measured mile trials. I think that so far as it is calibrated on the measured mile in calm water it is probably very reliable ; but did the author form any impression during the trials as to the loss of accuracy in the pitometer log in pitching conditions ? The accuracies stated in the paper tend to be on the optimistic side, even considering that the torsionmeter was calibrated on the shaft.

The question of roughness measurements is a matter of some difficulty because the data is not complete as between the " Lucy Ashton " and the " Lubumbashi," the actual measurements of physical roughness were not always made in the same conditions. If you take the comparable increases in grain roughness on the two vessels after six months, the increase in resistance on the " Lucy Ashton " is much greater than that on the " Lubumbashi," and that is a point of some considerable importance.

A further point is the amount of scum on a ship. It is definitely a fact that when a model has been in the tank for some weeks there occurs a scum which is smooth to the touch, but there is a marked increase to the resistance ; a ship which is docked after a long period at sea frequently has a similar slimy fouling, which cannot be measured with a roughness meter.

With regard to the determination of shaft losses, namely, an extrapolation to zero, I suggest that unless the operation is carried out to very low revolutions, one should not place too much reliance on this method of determining the friction of the tailshaft.

From the analyses of the weather results the interesting point is the rapid increase in the power required to maintain a given speed when the weather factor exceeds a certain amount. I think that there is a tendency to assume a rather low weather factor, and my inclination is to allow a weather factor rather larger than is generally acceptable. If you take a figure of 25 per cent at a Beaufort factor of 4 or 5 and there is fouling, I submit that an overall figure of 35 per cent is a very safe one to work with.

Mr. A. W. Davis : I am particularly interested in this relation between the increase of power and the idiosyncrasies of the weather. It is more or less the practice for vessels on the North Atlantic to allow an increase of power of about 30 per cent for maintaining speed under average weather conditions and with an average dirty hull ; from Fig. 16 it would seem that that is not an overestimate of the requirements. The author refers to the relative effects of running with diesel oil and with so-called heavy fuel oil. It would be interesting to have particulars of the actual oil used for the heavy brand, since it can be misleading merely to record the effects on an engine of a particular heavy fuel, because of the enormous variation between one fuel and another. It would also be interesting to know whether there was any change made in the spread between using the diesel fuel and the heavy fuel. The remarks by the author on hull roughness recall that our late naval architect used to allow an increase of power of 2 per cent per day out of dry dock.

Professor A. M. Robb : I would like to make a point which is stimulated by the remarks of Mr. Davis. Many years ago, in Liverpool, we always emphasised that if you do not rush ships out of dry dock, but allow them to stay there an extra day to enable the paint to harden properly, you will have far less trouble. You save far more than you lose by leaving them in dry dock for the extra day. In regard to ship-model correlation, Dr. Allan has omitted one point in regard to the model propeller in open water. It happens, very conveniently, that if you plot KT against KQ you will get very nearly a straight line, certainly over the working range, for the model. So far as the evidence is concerned for the ship, the spots are all above the line on the graph, and there is a considerable gap. I do not know the answer to that, the data being very limited ; but until we have solved that as part of the correlation problem we have not really tackled the correlation problem.

Mr. H. J. S. Canham : I am surprised that Professor Aertssen considers there is greater accuracy of measurement in the loaded trial than in the ballast trial, because only the ahead type of Michell thrustmeter was fitted. You can make a correction to take into account the weight of the shaft and apply that to the reading, therefore, why should there be less accuracy in the ballast trial.

The calibration of the torsionmeter on the shaft has prompted me to compare the figures, for accuracy, in the present paper with that of two years ago. In the present paper it is stated that the torque (the shaft being calibrated in the shop) was measured to an accuracy within 2 per cent in smooth water. Is that ± 1 per cent or ± 2 per cent ?

Professor Aertssen : It is ± 2 per cent.

Mr. Canham : In the " Tervaete " paper, Professor Aertssen quoted 3 per cent for an uncalibrated shaft. At B.S.R.A. we think that a figure of ± 3 per cent should be allowed. However, as, in the present case, the shaft is calibrated, we think that the torque measurements should be accurate to within $\pm$ 2per cent.

The B.S.R.A. has carried out tests on the thrustmeter, as the result of which it was concluded that an accuracy within ± 2 per cent was achieved. Professor Aertssen gives 4 per cent in smooth water and I would like to know why he considers that in smooth water the errors are within ± 4 per cent.

It is important in the measurement of hull roughness to measure that roughness at the time the ship is on trial, particularly the measured mile trial. Before the trials ships are coated with an anti-fouling paint and the period between the painting and the trials varies. Anti-fouling paint leaches into water and gets very soft, therefore, there is some action between the paint and the water as soon as the ship is undocked, and our hope of knowing what the surface is like at the time of trial is rather remote. I question whether the results obtained from test panels give much indication of the condition on the ship.

At the B.S.R.A. we have developed a mechanical gauge which gives a record of the profile of the shell surface and has the advantage that it can take a great number of records quickly. Professor Aertssen has used a pneumatic feeler, and a disadvantage of the pneumatic feeler is that it provides no record.

We cannot place much reliance on the pneumatic feeler readings, except to note that apparently they do register the increase of roughness over six months, and it would be better to rely on the figures interpreted through the boundary layer traverses, from which are deduced the equivalent sand roughnesses of the hull. It is interesting to note the astonishing increase that took place over six months and that that increase accounts for about 9 per cent in the total power. I cannot agree that the figures for the sand roughness correlate well with the measurements of the roughness of the hull established by the pneumatic method, although I admit that account must be taken of rust. I think the mechanical gauge can do just that for you.

I was surprised that the comparison of the ship revolutions per minute and model revolutions per minute at the same power absorption differed from the loaded to the ballast condition. In particular, in the loaded trials the figure is less than 1 ; it gives a factor, generally speaking, of 0·99, whereas in the ballast trials the figure was almost invariably over 1, except at top speed, from 1·02 down to 1. In a paper given before this Institution last year we gave results for thirty-seven ships, and in thirty-two of these the ship revolutions per minute were greater than the revolutions per minute predicted from the model.

Professor E. V. Telfer : In the problem of ship-model correlation, when the engine intervenes I have found that you must eliminate the engine from the ship and consider it as an engine only. So that the first step in correlation of this nature is to take your engine results purely as engine results and preferably adopt the following type of presentation. If you have ordinates of mean indicated pressure and a base of mean effective pressure, you can plot all the results for the particular engine, whether the tests were carried out in the ship in the loaded or the ballast condition, or on the test bed. You then take the particular value of mean effective pressure at a given point and draw it down from the total mean indicated pressure and you get a series of lines which possibly show a gradually increasing total loss of both static and running friction.

You can make that kind of diagram not only for the ship in question, but for all the engines you have, and produce a generic kind of diagram, which statistical analysis is much more reliable than any single set of information. That diagram should be your first guide in attempting ship-model correlation.

The next step is to analyse your trials. I would say to Dr. Allan and Mr. Canham that it is about time they were able to confirm the trial trips a little better than apparently they are able to do at the moment. For Heaven's sake see that you get results at fairly low revolutions.

The other point I want to make is in connection with the presentation of speed losses, particularly in Figs. 16 and 17. If you want to present information of this nature it would be better to present it in terms of the square of the wind velocity, which is most probably the correct linear cause of the speed loss ; I suggest that if Professor Aertssen can convert his diagram to the velocity squared diagram at the base, his speed losses and power losses will nearly linearise themselves, and he will be able to see the continuity of loss far better than at the present moment. The steep rise in the curve in going from Force 4 to Force 6, for example, is rather striking ; that steepness is entirely due to the Beaufort number not being really associated with the losses themselves, and I suggest that you have to go back to the air velocity in order to get a true correlation.

Mr. J. Foster Petree : I want to ask a question relating to the torsionmeter, which is stated to have been calibrated on the shaft. I do not see in the paper the diameter of the shaft and there is certainly no description of how the torsionmeter was calibrated. I have had some experience of calibrating optical torsionmeters on ships with shafts of up to 9½in in diameter, and as the shaft in this instance is obviously larger, I should like to know how it was done, because unless there has been a great advance in technique or unless an electrical torsionmeter simplifies the problem, it is quite possible that there may be a 4 or 5 per cent error in the calibration itself.

Mr. H. Lackenby : Dr. Allan has raised the question of the effect of scum, as against barnacles, grasses, &c., on resistance. We have some data on that which we obtained during the " Lucy Ashton " trials. The ship was tied to a buoy for forty days and there was a slight greasy scum on the surface. We ran the ship and measured the resistance in that state, and found that it had increased by 3 or 4 per cent over and above that measured in the previous condition, which corresponds to about 5 per cent on the skin friction.

Mr. John Brown : I wonder if Professor Aertssen will agree that in the analysis of the effect of weather on the performance, the size of the ship should also be a factor. A previous speaker has referred to a possible factor of 30 per cent increase of power as the average weather effect on the North Atlantic. I suggest that if there is a size effect, on the bigger ships the loss would be less than that ; even in the case of ships of moderate area I think owners accept a lower percentage than 30 as the allowance for weather. I have had the privilege recently of seeing some measurements made on one of our own ships and I admit to some surprise at the variation in thrust measurements, even in a measured mile run.

Commander Rupp (United States Navy) : In connection with corrections to thrustmeter readings, I also question the statement as to whether a two-way thrustmeter would give greater accuracy than a one-way meter. I would also ask the author whether the correction for the static head of the water due to the cross section of the shafting in way of the stern tube was considered. If it were not considered, it would explain some of the correlation information which is shown in both the tables for the ballast condition and the loaded condition. You will see the variation with speed. The correlation is considerably different when derived from developed and thrust horsepower. That derived from thrust is much higher in the low-speed condition, when the correction would be much greater, perhaps 6 to 8 per cent of the total thrust. In the high-speed condition that error may be only 2 per cent. If that had not been considered in these trials, the variations of the effective horsepower derived from thrust over those derived from Froude or Schoenherr would be more nearly constant over the speed range and more nearly constant with that derived from the horsepower data.

Another item concerns correlating increased power versus Beaufort wind correction. Wind has various effects There is wind resistance, there is still air, and its effects depend on how much of the area of the ship is above the water ; the wind also affects the condition of the sea. The still air effect was considered by Professor Telfer, and perhaps his method of plotting it would give the correct answer. But the rough water effect certainly will not follow any such law. It is directly dependent on the relation between the length of the wave and the length of the ship ; it becomes very much greater as the length of the ship falls nearly in line with the wave length encountered.

(To be continued)

Automatic Control of Modulating Oil Burners

FOLLOWING the introduction, early last year, of a range of low pressure air atomising oil burners, with single lever control and a minimum turn down ratio of 4 : 1, capable of running on the heaviest of grades of fuel oil, Whites Marine Engineering Company, Ltd., has announced the installation of these burners under fully-automatic control. The main advantage claimed for this burner was the combining of the oil and air controls in one lever so that no skill is required in operating the burner throughout its range, as oil and air ratios are pre-set and adjustment is provided to enable the maximum efficiency to be obtained from the lightest to the heaviest grades of oil. This ease of manual operation lends itself to a simplified form of automatic control, since once alight the boiler output is controlled by altering the position of the single lever actuated by a small electric motor under the control of a potentiometric controller.

An exploded view of the burner is shown in Fig. 1. Primary and secondary air enters the burner body through the flanged orifice (in this case air entry is arranged from above). On entering the burner the primary and secondary air travel forward together until they reach the primary air and oil nozzle housing, and at this point the primary air enters the housing through tangential holes, to give it swirl, and then past the oil nozzle at very high velocities. The oil nozzle consists of a robust steel body with a large axial orifice, $\frac{1}{16}$in for the smallest burners up to $\frac{1}{4}$in for the largest, feeding into a cup-shaped depression at the end of the nozzle. High-velocity primary air is directed at 45 deg. across the cup and the atomisation of the oil thus caused is effective throughout the range of the burner. The secondary air passes over this housing, is swirled at high velocity by the vanes at the end of the housing, and then expands through its own nozzle, augmenting the primary air and producing the efficient mixing essential for good combustion. The oil is supplied to the nozzle through a " V " groove and oil seal metering valve, the " V " groove being machined into the oil tube and the seal held in an adjustable carrier fixed to the body of the burner. The oil tube is fixed to the primary air nozzle housing, which in turn is linked to the operating lever mechanism. Hence, if the oil tube is moved forward, the opening between the " V " groove and the oil seal is reduced, so reducing the quantity of oil flowing to the oil nozzle. Simultaneously, the primary air nozzle is moved forward with the oil tube and cuts down the flow of the secondary air. Conversely, if the oil tube is moved backwards the oil flow and secondary air are increased.

As the controlling oil seal is mounted in an adjustable carrier, the " V " groove opening can be varied at will to suit oils of differing specific gravities, viscosities, &c., thus, by alteration of the oil/air ratio adjuster the burner is suitable for any commercial grade of oil without loss of combustion efficiency. It is stated by the makers that since the oil orifice is relatively large, there is no danger of the oil flow being blocked as in the case of certain air atomising burners and all pressure jet burners. In addition, as the oil velocity through the oil nozzle is very low, wear in the oil orifice is negligible.

As has been mentioned, the control of the burner is by movement of a single lever which

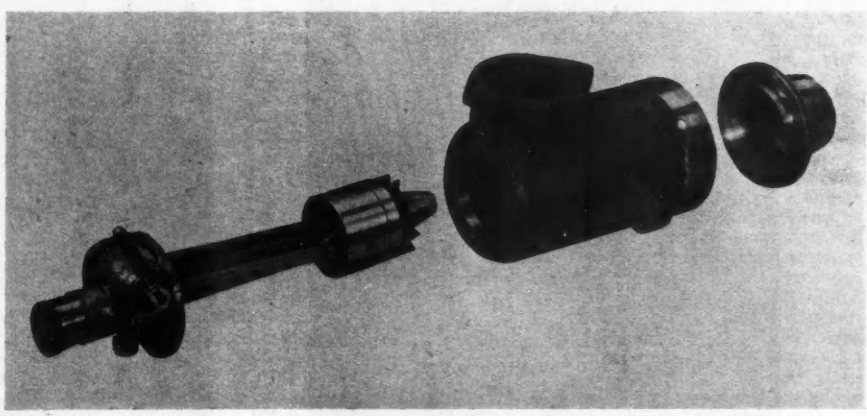
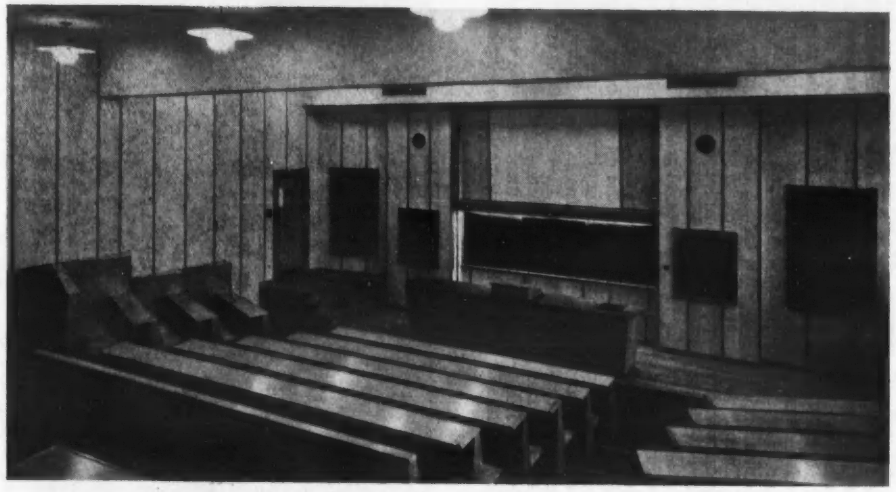


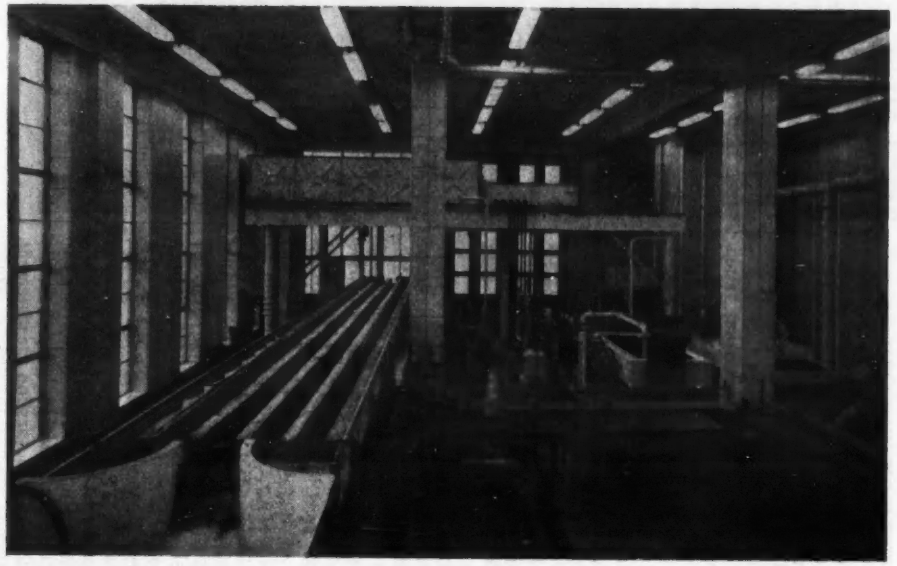
Fig. 1—Exploded view of the burner

ENGINEERING BUILDING AT SHEFFIELD UNIVERSITY



There are two lecture theatres seating 200 and 100 respectively, of which this is the larger. They are arranged back-to-back and served by a single lantern projection room

There is a work room for each group of students and a work table for each individual student. Work rooms such as this can also be used as a drawing-office or lecture room



The hydraulics laboratory contains a wave tank 30ft by 26ft 6in by 3ft deep, and an open channel 3ft 6in wide by 3ft deep by 50ft long, besides the usual turbines and pumps. A research is being conducted on flow in channels of variable cross section

The materials testing laboratory is equipped with the usual machines for tension, compression, bending, torsion, impact and hardness tests. A combined torsion-tension machine was designed and made in the Department and is sited in this laboratory

gives a turn down ratio of at least 4 : 1. Automatic operation of the lever is through a potentiometric motor which, in turn, is controlled by a bridge resistance actuated by pressure when used with boilers, or temperature when associated with hot water systems, furnaces, chemical reactors, &c. The contact on the resistance bridge having been moved to a new position by the pressure or temperature device, the motor immediately turns in the correct direction until a balance is obtained in the bridge circuit and the motor stops. Thus, it is possible to obtain automatically the "stepless" control of the lever throughout the whole of the turn down range of the burner. Fig. 2 shows a typical two-furnace land boiler and the modulating motor and linkage, &c., can be seen attached to the burner.

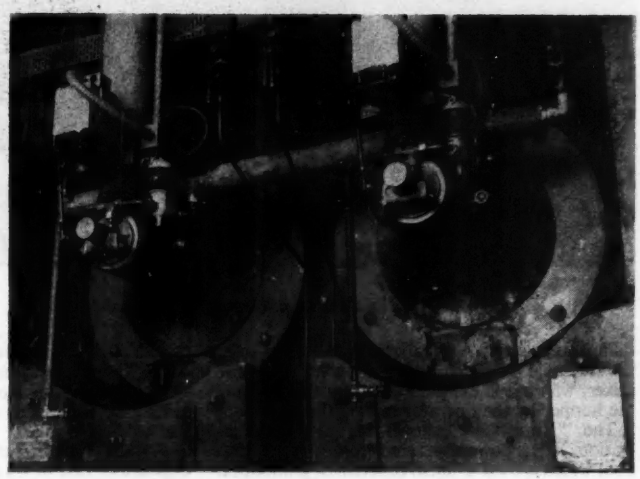


Fig. 2—Typical two-furnace land boiler showing modulating motor and linkage to burner

The rest of the automatic system so far as sequence of operation and safeguards are concerned is as follows: oil temperature and pressure are controlled, respectively, by thermostat and pressure regulating valve and on starting up the oil heater and pump are switched on by a common push button. When the oil is up to the required temperature and pressure, as indicated by line thermostat and pressure switch, then the blower can be started up. The next sequence takes place only when the pressure switch in the air duct indicates that the fan is running correctly. This is the energising of the spark igniter, followed by the opening of the oil magnetic valve. If the burner lights up within fifteen seconds, the controlling motor moves the burner lever to the correct position. If not, one further fifteen-second period of ignition is allowed without reinitiation of the starting sequence. After that, if the burner does not light, the equipment shuts down.

When starting from cold the lever moves to the fully open position, but if relighting takes place and the boiler is at the correct pressure, the lever will move to the required position. At this stage the automatic equipment is said to be in the operating condition and the burner will continue to run unless one of the five safeguards mentioned below causes complete shut-down. (1) Excessive boiler pressure which actuates a separate excess pressure switch. (2) Low water level which actuates a low level cut-out switch. (3) Flame failure which is indicated by the flame failure device which shuts down the equipment, but also initiates the operation of a relight. In the event of a relight not taking place, the equipment shuts down completely. (4) and (5) The blower air pressure switch and the oil pressure switch already mentioned in the lighting-up sequence go into operation on loss of oil pressure, oil temperature or air pressure, and shut-down the equipment immediately.

It should be mentioned that on starting up and before ignition commences, the blower is run for a specified period to allow unburnt gases to be blown out of the furnace, and this "purge" period can be altered to suit conditions. It is achieved by means of a timing relay which prevents the operation of the next sequence until the specified period has elapsed. The igniter is of a new pattern and consists of a high-temperature steel plug with central anode which throws off at approximately one second intervals a series of large sparks into the path of the oil spray. Unlike some existing high voltage igniters, deposits of oil and carbon on the plug improve the spark and positive lighting is assured.

On the control panel indicating lights are provided which indicate the following: Mains Switch "On"; Boiler Switch "On"; "Purging"; "Purging Completed"; "Flame Established"; "Flame Failed"; "Low Water Level"; "Low Oil Temperature"; "Low Oil Pressure"; "Draught Failed." An audible alarm is provided to draw attention to any failure causing shut down.

Where an induced or forced draught fan is fitted, the starting-up of this fan can be coupled with the starting-up of the blower without there being any additional sequences.

Where two or more burners are provided on one boiler or furnace, separate circuits are provided for ignition and flame failure for each burner, thus avoiding complete shut down in the event of any one burner failing. The rest of the automatic equipment is not duplicated and all burners are started up and modulated together. Both manually controlled and automatic "Unitrol" burners are manufactured in standard sizes varying from 3 gallons per hour to 45 gallons per hour normal maximum output. In each instance this represents the output when all the air is supplied by the blower, i.e. the burner is not fitted with an air register. Under natural draught conditions the output of the burner can be doubled, by means of an air register, in which case only 50 per cent of the air is supplied by the blower. Under forced, induced or balanced draught conditions, the output of the burner can be increased up to about four times its normal output by the same means and in these cases only about 25 per cent of the air is supplied by the blower. In such arrangements the air register damper is interlocked with the burner lever so that the arrangement is still controlled by a single lever. Thus, it is possible to use the "Unitrol" burner for outputs as high as 180 gallons per hour under manual or automatic control while keeping the blower power well within accepted figures.

Engineering Building at Sheffield University

On Wednesday of last week, as recorded elsewhere in this issue, a new engineering building was opened at Sheffield University.

The building stands on sloping ground on the north side of the St. George's Square site and has a volume of nearly 1,500,000 cubic feet. It is of the usual type of reinforced concrete frame construction with concrete panel walls faced on the outside with brickwork. It has three main floors and these are (or will be) continuous with corresponding floors in the front and back blocks of existing buildings. It houses the whole of the Department of Civil Engineering and most of the Department of Mechanical Engineering which, however, will still retain some rooms in the back block of the old building. The Department of Electrical Engineering has thus been left free to expand into rooms in the front block of the old buildings vacated by the other departments, though it will also have some work room and lecture room accommodation in the new building.

The two upper floors (B and C) of the new building are both on single levels, coincident, respectively, with those of the B and C floors of the old front block. The bottom floor (A) is at the same level as the old A floor where it meets the front block, but a considerable fall in ground level down Broad Lane has made it possible to drop the level of most of the new A floor so as to provide greater headroom in those laboratories which house large equipment, and to leave room for a mezzanine floor along the north side of the building. At the east end the fall of ground level has also made it possible to provide a subground floor containing one laboratory and the heating boilers, electric substation and other services for the whole of the Applied Science Buildings.

In general the planning of the new building and the allocation of its rooms have been based on functional considerations. On the A floor are those laboratories requiring heavy equipment, considerable headroom or underfloor services. On the top or C floor are lecture rooms, drawing offices and most of the work rooms. On the intermediate B floor are the lighter laboratories, a photographic suite, a few work rooms and a museum. Private rooms for staff are provided on both B and C floors and along the mezzanine corridor. Lecture rooms and work rooms for students have been located on the south side of the building, as far away as possible from street and laboratory noises.

The system of student work rooms, one of which is illustrated, is a feature of the new building and of the kind of curriculum for which it has been planned. In a non-residential university it is held specially important that every student should have a place where he can go for private study at any time, day or evening, when he is not receiving formal instruction, and where he can obtain tutorial assistance or discuss his work with other members of his own group. In the new engineering building there is a work room for each group of students and a work table for each individual student. A work room can, of course, be used without interference with its special function, as a drawing office and lecture room for its own particular group.

In order to broaden the appreciation of students and to preserve objects of historical interest to engineers, more particularly in connection with the industries of the Sheffield district, one room in the new block has been set aside as a museum. This already contains several notable exhibits which have been presented to the University—and there is room for more.

The new building which has now been opened is essentially part of a comprehensive scheme of extension and reorganisation of the three Departments of Engineering. So far as the Department of Civil Engineering is concerned the scheme is complete. In order to complete the scheme for the Department of Mechanical Engineering, structural extensions and alterations to the existing back block have now been undertaken, which will provide administrative offices, additional work rooms for undergraduate and post-graduate students, and larger and better equipped laboratories for applied mechanics, steam engines and mechanical research. At the same time, internal structural alterations on three floors of the existing front block will provide adequate teaching and research accommodation for the enlarged Department of Electrical Engineering and for the extensive and up-to-date equipment which it has been acquiring for some years in preparation for its expansion. Some photographs of the new building are reproduced on page 640.

Following the increase in accommodation provided by the new block and consequent alterations to existing premises, further expansion of staff and reorganisation of departments have been made possible by the University Grants Committee. In future the three departments of civil, electrical and mechanical engineering will be independent, each under its own professor. The Professor of Civil Engineering will have five lecturers (or assistant lecturers), the Professor of Electrical Engineering six, and the Professor of Mechanical Engineering ten. The total teaching staff of three professors and twenty-one lecturers will be able to handle an annual intake of ninety engineering undergraduates and of up to twenty post-graduate students, and also to provide courses in engineering subjects for other technologists and for architects.

Concrete Batching and Finishing Equipment

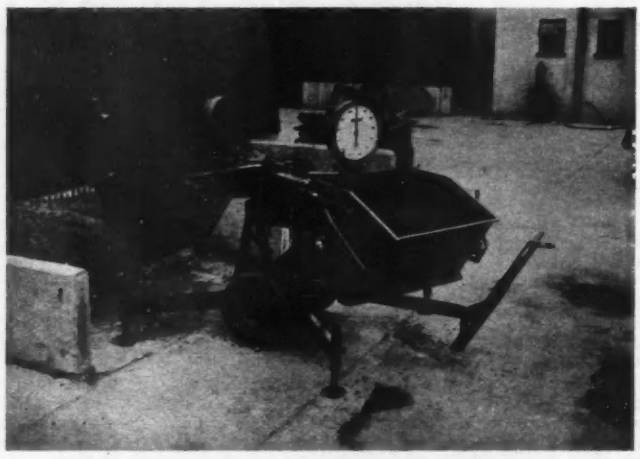
PARTICULARS have been received from Winget, Ltd., Rochester, Kent, of some new equipment it has introduced for concrete batching and finishing. One of the new machines is the portable swing weigh batcher illustrated below. It consists essentially of a welded steel chassis on the head of which are pivoted radius arms carrying two independent skips, each of which can be swung round an arc of 180 deg. These skips have a capacity for 10 cubic feet and each assembly incorporates a weighing mechanism with a large dial.

Power-operated rotary trowel or float for finishing concrete and granolithic surfaces

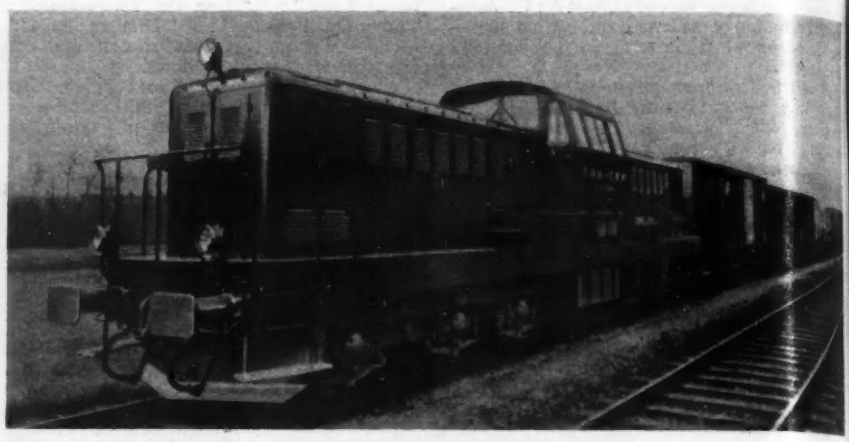
Depression of a lever to discharge a skip swings a skip forwards and over a mixer hopper so that the contents are discharged well up towards the hopper throat. The machine is balanced on its two pneumatic-tyred wheels for ease of manœuvring and when in position is supported by outrigger jack arms.

A drag scraper now available for the firm's "7 NT" and "10 NT" mixers can be used for scraping ballast from a large stockpile and depositing it into the mixer hopper. For this appliance a jib structure mounted on top of the mixer has its pulley centred above the mixer hopper in its lowered position. The line of the scraper bucket is operated by a power-driven winch on the mixer. The bucket is fitted with handles and is guided manually during the filling operation. As the bucket is pulled over the stockpile it is filled and then drawn up to the mixer, where it is elevated and then tipped into the hopper by the operator raising the handle.

The "Rotorfloat," shown in our first illustration, is a power-operated rotary trowel or float which is used to finish concrete or granolithic surfaces. It has three blades which are rotated by a 1½ h.p. petrol engine, and it is drawn over the surface to be finished by a long handle carrying the drive controls. The angle of the finishing blades is adjustable from the horizontal position up to 16 deg. to suit the surface being treated.



Swing weigh batcher. Either of the two independently mounted skips can be loaded at any point within an arc of 180 deg., while the other skip is being discharged into a mixer hopper



1700 b.h.p. diesel-electric Co-Co locomotive

1700 B.H.P. Diesel Locomotives for Switzerland

FOUR 1700 b.h.p. Sulzer-engined freight-transfer and heavy shunting diesel-electric locomotives, which have recently been put into service by the Swiss Federal Railways, are claimed to be among the largest and most powerful locomotives of their kind outside of North America. Each of these locomotives has an all-on weight of 104 tons and their starting tractive effort of 73,000 lb can be exerted and sustained up to about 5 m.p.h. One of the locomotives is shown at work in the illustration above.

As can be seen, a double six-wheel bogie C_0–C_0 wheel arrangement has been adopted, and the two 850 b.h.p. Sulzer engines and associated electrical equipment are arranged in separate casings, one each side of the central cab. Leading locomotive particulars are: wheel diameter, 41in; bogie wheelbase, 12ft 6in; total wheelbase, 42ft 3in; overall length, 55ft 8in; maximum axle load, 17½ tons; one-hour tractive effort rating, 41,800 lb at 9·35 m.p.h. As it was desired in certain circumstances, such as in the event of current supply failure on the electrified routes, to work heavy trains in line service with the new locomotives, they were designed for a top speed of 46 m.p.h. and the wheel rim tractive effort at that speed is 6600 lb. The layout of the central cab is unusual, in that there is a single central driving desk with a driving position at each side.

Each diesel generator group comprises a "6LDA25" pressure-charged engine, set to give a top output of 850 b.h.p. at 850 r.p.m. and with a continuous output of 750 b.h.p. at 800 r.p.m. The engine is of welded steel construction with the crankcase and underbed as one structure, which is extended to form the generator underbed. The single cylinder block, also of welded steel construction, has wet liners inserted, and individual cast heads each house one inlet and one exhaust valve.

A 472kW main generator is driven by each engine and carries on a shaft extension a 46kW, 150V auxiliary generator. The six force-ventilated nose-suspended traction motors each have a one-hour rating of 143kW and drive through two sets of single-reduction gearing, one on each side of the motor carcase. A servo field regulator control system is fitted to the engine to prevent overload and to ensure that it runs under favourable conditions of load and speed according to the tractive requirements. The electrical control system of the locomotive enables either one or both engines to be run under load, and to have all six or only three traction motors supplied with current.

Loch Glashan Hydro-Electric Scheme in Argyllshire

WE learn from the North of Scotland Hydro-Electric Board, that the waters of Loch Glashan, Argyll, are to be used for power generation under a scheme prepared by the Board and confirmed by the Secretary of State for Scotland, the Rt. Hon. James Stuart, M.P. The scheme which will produce about 17,600,000 units of electricity annually, is required to help to meet the rapidly growing demand for electricity in the Kintyre and Knapdale areas. The loch lies in the hills behind Lochgair on Loch Fyne. The natural catchment area of Loch Glashan is 4 square miles and, by diversion aqueducts, use will be made of the rainfall on a further 20½ square miles including part of the catchment of the River Add, which flows into Loch Crinan. All the water will be impounded behind a dam, 1100ft long and 45ft high, to be built at the outlet of Loch Glashan. From the dam water will be taken by a tunnel and pipeline 5500ft long to a power station with an installed capacity of 4200kW situated on the shores of Loch Gair, into which the water will be discharged. The scheme is estimated to cost £1,300,000. The statutory Amenity Committee recommended that in designing the power station attention should be given to the fact that the back of the station will be towards the road and the Board have accepted this recommendation. The committee may make recommendations later on such matters as the designs of the structures to be erected under the scheme, the concealment of pipelines, &c., and the siting of spoil dumps. In the interests of fish preservation in the catchment area of the River Add, the Fisheries Committee made recommendations on the amount of compensation water to be given on waters affected by the scheme and the provision of fish ladders and screens, all of which have been accepted by the Board. A White Paper on the scheme has been published and is available (price 3d.) from H.M. Stationery Office, 13a, Castle Street, Edinburgh.

Air- and Water-Cooled Diesel Engines

By HELMUT MEYER*

Abstracts are reproduced herewith of a paper, "The Relative Merits of Air and Water Cooling for Tractor Engines," which was read by the author before the Institution of British Agricultural Engineers on Tuesday, April 19th. The essential characteristics of the engines are compared and comment is made on design, maintenance and performance aspects.

Now I could attempt to give you in a long table a summary of German air- and water-cooled diesel engines, but instead of that I should like to restrict myself to two kinds of examples, in which, first, the combustion and working processes emerge, and, secondly, engine power and weight.

Fig. 1 shows with what result the various combustion, scavenging and charging processes are used for mean effective pressure (m.e.p.), which results from the maximum capacity of the engine and the motor revolutions. The cubic capacity of the water-cooled engine is between 28 and 116 cubic inches per cylinder and of the air-cooled engine between 24 and 87 cubic inches per cylinder. In water-cooled engines all combustion processes occur, whereas in the air-cooled engines only whirl chamber air is used either in the cylinder head or the piston. The mean effective pressure with water cooling lies between 80 lb and 110 lb per square inch. On an average one can reckon with 90 lb to 95 lb per square inch. I should like to draw special attention to the engine with precombustion chamber and Roots blower, which reaches by means of the charge a mean effective pressure of about 110 lb per square inch. In air-cooled engines the variations are substantially higher, the mean effective pressure lying between 70 lb and 115 lb per square inch. The latter value has to be considered as very favourable and unusual. As an average one can take approximately 85 lb per square inch.

The next illustration (Fig. 2) shows the ratio of the two-stroke motors, the number of types here being essentially lower. The cubic capacity per cylinder of water-cooled engines lies between 30 and 450 cubic inches and of air-cooled engines between 18 and 78 cubic inches. Surprisingly, a mean effective pressure of straight 70 lb per square inch is obtained in a water-cooled engine by using a Roots blower and in an air-cooled engine by uniflo-scavenging. In the three above-mentioned big cylinders with water cooling with which the new Lanz "Bulldog" diesel engines are concerned, the stated mean effective pressure corresponds to the statement of the firm. In fact, values in the region of 70 lb per square inch have been measured at a standard efficiency of the engine. The values for mean effective pressure of air cooling are in general lower than those for water cooling, only engines with uniflow scavenging producing above 60 lb per square inch. This, however, calls for a more expensive motor.

Now there appears the question whether the reduction of the mean effective pressure by air cooling affects the weight of the engine. Fig. 3 gives the answer. Here type series of four-stroke motors with one to four cylinders have been used as examples. Influencing the weight per horsepower are the revolutions, the cubic capacity per cylinder, and especially the number of cylinders. The comparison of different type series is somewhat prejudiced because some of the motors are self-supporting, and others have to be mounted in special frames. However, it has to be remembered that the weight of the water-cooled engine does not include that of the radiator, whereas in the air-cooled engine the whole cooling system is included. I should like to sum up by saying that air-cooled engines are at least not heavier, but rather lighter in weight than equally powerful water-cooled engines, including their radiators. A comparison of the weight of the two-stroke engine is unfortunately not possible, as these are not as much type series, but rather one, at the most two, cylinder engines, besides which they differ considerably in their equipment and construction. The lowest weight per brake horsepower of a two-stroke engine was found to be 11 lb per horsepower in an air-cooled, two-cylinder engine.

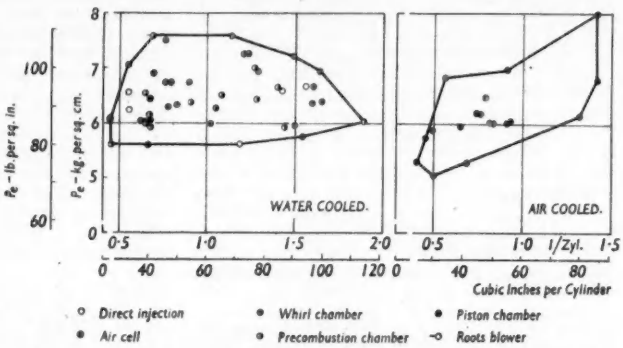
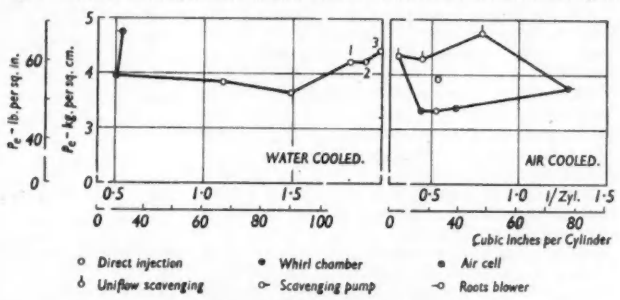


Fig. 1—Mean effective pressures of water- and air-cooled four-stroke diesel engines



(1) 2·26 l/Zyl. = 138 cubic inches per cylinder.
(2) 3·71 l/Zyl. = 226 cubic inches per cylinder.
(3) 7·35 l/Zyl. = 448 cubic inches per cylinder.

Fig. 2—Mean effective pressures of water- and air-cooled two-stroke diesel engines

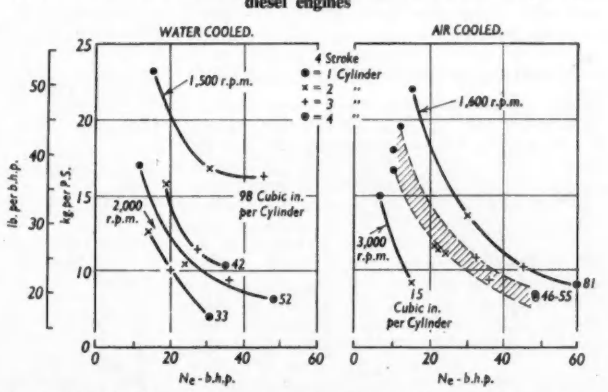


Fig. 3—Weight and brake horsepower of water- and air-cooled diesel engines

Constructional Details of Air Cooling

In the air-cooled diesel motor, the arrangement of the cooling blower limits the external picture to a great extent.

The simplest form of a blower results then when it is connected immediately with the flywheel as a radial blower. [The Deutz one-cylinder and two-cylinder motors were illustrated.] Perhaps a three-cylinder motor could still be sufficiently cooled with a flywheel blower, but this is nearly impossible with the four-cylinder motor. Therefore Deutz has gone over here to a separately arranged axial blower. Its lateral arrangement makes the air-cooled series motor broader than the equally powered water-cooled motor, but for the same reason such a motor is also shorter.

If one wishes to cool all the series from one to the multi-cylinder motor uniformly, one must be prepared to use with the one cylinder the lateral axial blower. From Deutz I here point out the one-cylinder and the eight-cylinder V-motor which has, until now, never been used in a tractor.

With the Stihl two-stroke motor, having uniflow scavenging, the axial blower is set only a little sideways across from the cylinder; nevertheless, it is still possible to cool the second cylinder adequately.

The conduction of the air around the cylinder is very important. Great differences of temperature present at the inlet and outlet sides and in the cylinder wall cause a distortion of the cylinder, and a jamming of the piston can be avoided only through having much play. The temperature can be kept sufficiently constant by the formation of the fin and the arrangement of windblast area.

The finning of the cylinders and of the cylinder head has a great influence on the heat educed and because of this on the maintenance of the desired form. During the last few years the so-called spike cylinders were introduced with great success. They reduced the danger of getting out of centre even when through-passing fixing screws are used. The finning of the cylinder head is particularly difficult, especially those with combustion chambers.

With air cooling special attention has to be paid to the heat supply from the cylinder head to the cylinder being adequate. To avoid any disturbance here, the use of special linings has been done away with. This presumes that cylinder head and cylinder are not distorted at the contact surfaces. The fixing of the cylinder head to the cylinder block and from this to the motor casing is very often done by through-passing stud bolts. There is a very real danger that, by tightening these bolts, the cylinder head and cylinder will be braced. Exact instructions about the tightening of the nuts are needed to prevent such a bracing, which can also be counteracted by grinding and polishing the cylinder in a tightened condition. In water-cooled motors great efforts are also made to prevent a bracing of the cylinder block by tightening the cylinder head screws.

Air-cooled engines are different in construction and development from water-cooled engines in that every cylinder with its cylinder head portrays one unit. About the enlargement of the cylinder median space by these single cylinders one gets in general a wrong idea. Actually, the space of the cylinder median in comparison to the cylinder diameter in the air-cooled motor is not bigger than that of the water-cooled engine.

In the construction of the cylinder head, in particular of the valve cap, consideration must be given to the fact that an air-cooled engine has to be absolutely oil tight, otherwise, in dusty operations which are predominant in agriculture, one has to reckon with clogging of the radiator fins and with a reduced cooling effect.

The cooling system, the material and the construction of an engine are closely related. Cast iron is used at the present for the heads and the cylinders of water-cooled engines for diesel tractors. In Germany wet cylinder bushes are generally preferred to dry ones. For air-cooled engines light metal is principally used for the heads, as its heat conducting powers are three times as high as that of cast iron. Generally cast iron is used for the cylinders, though in one

* Braunschweig-Volkenrode.

case a bush of cast iron is pressed on to a light metal casing, the latter being finned. Chromium plated light metal cylinders are not yet used in engines for tractors. Because of better heat conducting properties light metal for pistons has become universal. Piston construction and shape are mainly determined by the combustion process and cooling system. It is generally said that, with a cylinder diameter of about 100mm the piston clearance for water cooling should be about 0·03mm. Air cooling requires a greater clearance, but I believe that this can be reduced by better control of heat dissipation.

In water-cooled motors it is becoming increasingly common to fit the air induction pipe and the exhaust pipe on the same side of the engine. The same points of view are valid for the air-cooled motor. The conduction of the cooling air to the cylinders is simplified, if not interrupted, by intake or exhaust pipes or other obstructions. In this case the air-cooling system has to take into account only the injection nozzle. If the push-rods of four-stroke motors are at the air outlet side, they are heated together with the cylinder without special steps.

One also will strive to set those cylinder walls to work which show the highest slide way pressure. In engines with the usual turning direction of the engine, seen in the driving direction, the blower lies on the right side of the engine.

Temperature and Wear of the Air- and Water-Cooled Engines

Since the war the use of mineral oil from the Near East has, not only in Germany but in other European countries, raised the content of sulphur in diesel oil from 0·2 to 0·3 per cent in former times to 0·6 to 1·2 per cent now; on the average, 0·8 per cent. This increases the wear on the cylinders of diesel engines. During the war heavy-duty oils were developed in Great Britain and the U.S.A. in which the additives reduce the unfavourable effects of the sulphur.

Comparative experiments with heavy-duty oils have been carried out in my institute by Dr. Seifert since 1949, and in 1950 an air-cooled diesel engine was included. We ascertained at that time an extremely low wear of that particular engine, which could be explained by the higher temperature of an air-cooled motor. This

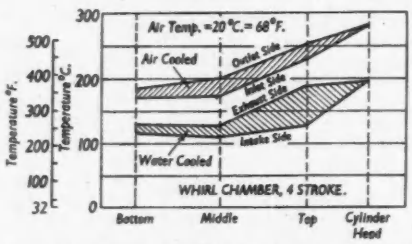


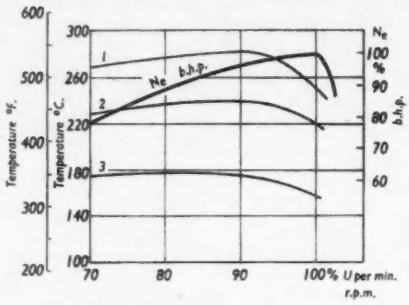
Fig. 4—Maximum temperatures of water- and air-cooled diesel engines at full load

observation has led to extensive examinations of the temperatures of air- and water-cooled engines and their wear.

We determine the temperatures by placing thermo cells in all critical positions; e.g. with four-stroke motors in the cylinder head between both valves, and in the cylinder in the upper and lower dead point position of the first compression ring, as well as at the air inlet and outlet side. The thermo cells are induced from outside, the measuring point lying about 2mm under the inside surface. In this way one-cylinder motors are equipped with up to thirteen measuring points. For the test the motors are already installed in the tractor, which is of completely normal construction. It is loaded by means of a checker, on which all gauges are present.

In Fig. 4 the highest temperatures are shown for two rather similar motors with whirl chambers, of which one is water cooled with thermostat, and the other is air cooled without thermostat. The temperature field of the air cooled motor lies essentially higher, and the difference between the air inlet side and the air-outlet side, thanks to the good air-conduction, is not very great, but perhaps it could be still less. On the other hand, at the top dead point of the water-cooled cylinder compression ring there is a great difference between the air suction side and the exhaust side. The effect of the hot exhaust valve is noticeable as far as the cylinder wall. An improvement in water conduction could reduce the high temperature in this position.

We have not considered it necessary until now to measure the piston temperatures, as according to other tests they are not dependent on the cooling method, but on the combustion process. They were ascertained to be around 200 deg. Fah., higher with precombustion process than



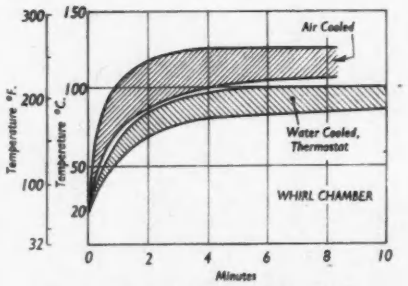
Whirl chamber, four stroke.
(1) Cylinder head } Mean temperature.
(2) Cylinder top
(3) Cylinder bottom
Air temperature 20 deg. Cent. = 68 deg. Fah.

Fig. 5—Temperatures of an air-cooled diesel engine at full load

with direct injection. Fig. 5 shows the temperatures of an air-cooled diesel motor with whirl chamber at full load in the range of 70 to 100 per cent of maximum revolutions. From this it follows that the temperature of the motor rises as the revolutions drop and reaches its maximum at 90 per cent of the revolutions. Measurements on other motors showed that the temperature lowered as soon as the motor ran under half the normal number of revolutions. This test produced the proof that there is no danger created by a drive of a loaded air-cooled motor of usual construction, with lower revolutions, although the efficiency of the blower is greatly diminished by this.

With two-stroke motors of uniflow-scavenging we found a similar distribution of the temperatures as with the four-stroke motors. On the other hand, higher temperatures occur with the motors having the usual inlet and outlet slits. Heat eddies at the outlet slits in a water cooling system are, perhaps, more easily avoidable, especially if the heat load, thanks to supercharging, is large.

There was further research into the question of how temperatures changed with air- and water-



Air temperature 20 deg. Cent. = 68 deg. Fah.
Idle running at maximum revolutions per minute.

Fig. 6—Increase of cylinder temperatures (top) after starting

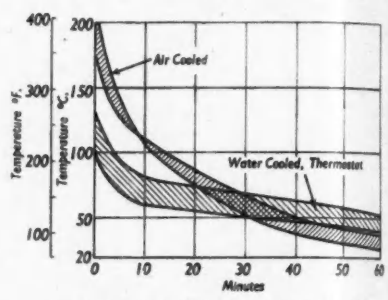
cooled motors in idle running and similar situations.

Fig. 6 shows again the ascent of average cylinder temperatures, measured in the plane of the upper dead point position of the first compression ring. From this it can be seen that, for fast idle running, air-cooled motors warm up more quickly than water-cooled ones, even if they are equipped with a thermostat. But even the warming up time of water-cooled motors is relatively short as after one-and-a-half minutes the temperature of 150 deg. Fah. has been surpassed. With slow idle running the results are similar, but the total temperature range has been decreased. It is now generally prescribed, in contrast to the past, that shortly after starting the motor, the tractor should be set in motion, in order that the motor is stronger loaded and the time in which it works with cold cylinder walls will be minimised.

Although the temperature of an air-cooled motor drops more quickly when it is switched off than does that of a water-cooled one, because the former heats up more quickly than the latter, its proportional time of running at a dangerously low temperature is approximately the same (see Fig. 7).

Doubts have been expressed about the efficiency of cooling when air-cooled tractors are used in hilly districts. Going downhill the engine can be used for braking in the ordinary way, running at full revolutions with the throttle closed and the blower working normally. At our tests we used the following procedure: first a tractor was fully loaded by the checker, then the load was removed and the tractor was pushed by the checker. Every nine minutes the procedure was reversed to reproduce the effect of hilly country.

Fig. 8 shows that, at the end of the slope distance, the air-cooled motor is always a little warmer than the water-cooled motor, but both motors are in a range that does not imply any danger in a rapid cooling off or with regard to



Air temperature 3–13 deg. Cent. = 37–55 deg. Fah.

Fig. 7—Decrease of cylinder temperatures (top) after stopping

condensation of water in the cylinder and formation of H_2SO_3 and H_2SO_4.

The conclusions drawn from this series of tests are as follows: agreement exists that water-cooled motors should be equipped with a thermostat, and where frequently low outside temperatures occur a radiator shutter would also be desirable. The thermostat throttles the water flow through the radiator below a particular temperature. With the usual construction comparatively cold water, of course, in a small quantity, then flows back into the motor. By the so-called two-cycle cooling applied by Hanomag, the circulation of water is maintained even at a closed thermostat, but little or non-cooled water will be conveyed to the motor.

With air cooling a regulation of the tempera-

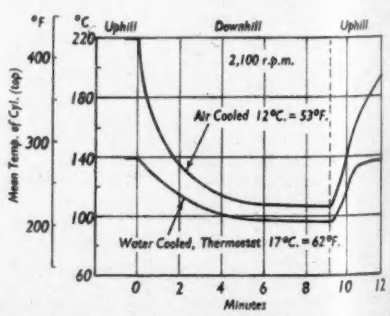


Fig. 8—Temperatures uphill and downhill of four-stroke diesel engines (whirl chamber)

ture seems less necessary than with the water-cooled motor. Air-cooled motors used in Germany and countries with a similar climate are not provided with a means of regulating the air cooling temperature or cool air quantity. In a few motors it can be regulated by hand when a thermometer must be at hand as an indicating device. For operation in cold regions, however,

an automatic regulator of the air cooling temperature will be necessary.

In very high outside temperatures, e.g. in the tropics, the efficiency of the blower on the air-cooled motor as well as on one of the ventilators on the water-cooled motor, and its radiator size, can be adapted, but this would be necessary earlier with the water-cooled motor.

In this connection I have to point out details of oiling, not only of sliding surfaces, but also to aid in heat eduction. In air-cooled motors with splash-fed oiling, which means four-stroke motors and two-stroke motors with loading blower or pump, a sufficient heat eduction can only be achieved by motor oil, either by a sufficiently high heat-emitting surface of the motor casing or by a special oil cooler.

If the whirl chamber is adjusted to the piston more heat must be carried off by the motor oil. With the enlargement of the cubic capacity of a motor and also with the increasing of the number of cylinders, it would be necessary to use a special oil cooler, particularly for use in the tropics.

I now turn to the results of our tests to ascertain the wear of air- and water-cooled engines. We carry out measurements of wear in this way: we ascertain exactly the measurements before the beginning of the operation and check them regularly during the operation on agricultural plants in regard to oil consumption, oil condition and wear. Naturally these tests are liable to some error, yet on the whole they give a good picture.

The life of a cylinder is definitely determined by means of its wear at the upper dead point position of the first piston ring and through the wear of the piston ring itself, which has an effect on the wear of the other piston rings. The superiority of the heavy-duty oils over the normal oils has been unequivocally demonstrated. With normal oil, oil sludge settles in the piston ring slots, especially in those of the oil scraper rings. The compression rings clog up longer with heavy-duty oils, consequently the combustion gases also blow through less strongly.

The effect of combustion on the wear of cylinder and piston rings has been decisively shown. It depends on different factors, especially on the combustion system, the arrangement of the injection nozzle, the highest temperature reached by it, and the adjusting of the conveyed amount of the injection pump in relation to the smoke limit. Bad, frequently smoking combustion has led, in our tests, to a high wear equally on the air- and water-cooled motors. This influence seems to overshadow all other influences.

If the combustion with full load is faultless and free from smoke, then in general the wear may not be higher than with the part load.

With motors of faultless combustion, average load and good service we have been able to obtain equally good wear conditions independent of the cooling method.

We have come to the following conclusions for cylinder wear at the position of the upper dead point of the upper piston ring. They are related to a diameter of about 4in. A wear of about 10/100mm for 1000 hours can be regarded as good, one of about 6/100m to 7/100mm as very good, but one of 20/100mm for 1000 hours as bad.

The assumption that the wear of the cylinders with air-cooled motors is basically lower than with water-cooled ones has, therefore, no support according to our experiments. Independently of the cooling method the general overhaul times lie, according to the permissible wear of the cylinder, between 2500 and 6000 hours.

Here I should perhaps point out that any removing of a piston for the control of wear and soiling spoils the sliding quality after reinstatement, even if one takes great pains to procure the same position of the piston rings.

Advantages and Disadvantages of Air and Water Cooling

I will now attempt to summarise the advantages and disadvantages of air and water cooling from the above results, which lead to the following conclusions :—

(*a*) *In Regard to Construction.*—For the construction of effective water-cooled engines more experience has so far been gained than for air-cooled engines, so that a longer time for developing the latter has to be considered. In any case close co-operation between the materials specialist and the flow specialist, the designer of the piston and the other parts of the engine is to be desired. The maintenance of a good heat transition between the various parts and mediums requires special constructional precautions.

The single cylinder of the air-cooled motor permits the comparatively simple development of type series.

(*b*) *Production.*—Here, too, the single cylinder of the air-cooled engine receives favourable notice. The transport weights and volume of production are, up to the fitting of the engine, essentially diminished. In contrast to that, more locating surfaces on the motor case have to be machined.

The machining of the cylinder running path, lining and locating surfaces between the cylinder head and the cylinder generally require a higher precision in the air-cooled engine than in the water-cooled one. The guttering of the combustion chambers into light metal heads and the connection between cast iron and aluminium in cylinders requires special processes and fittings.

(*c*) *Working Conditions.*—The cooling system has no important effect on the specific fuel consumption of the motors. The combustion process is decisive.

The noise of air-cooled engines is as yet greater than that of water-cooled ones. This results from the fact that the silencing effect of the water jacket and the outer motor wall is dispensed with. In so far as the noise is caused by the spin of the piston, it is reduced even more if the clearance between the piston and cylinder is as small as it can be. A careful disangling of the piston-rod can diminish the noise.

The care required in servicing is, without doubt, less with air cooling than with water cooling. Any worries about lack of sufficient water or freezing in cold weather are dispelled with the air cooling systems. The independence of water is particularly favourable in regions with high temperatures and lack of water, and the insensibility to cold can be decisive if personnel is frequently changed or unreliable.

(*d*) *Wear and Repair.*—With careful construction of a motor the cooling system has no influence on wear. With both cooling systems, according to our experiments, the general overhaul times lie between 2500 and 6000 hours.

In the repair shop the single cylinder of the air-cooled motor is remarkably convenient for storage, provided, of course, that a closed type of series has been developed.

Experimental Rail Containers

During the past year the North Eastern Region of British Railways has been experimenting with small-wheeled containers which may, it is thought, herald a new service for traders in providing door-to-door transport with reduced packing costs, lessened risk of damage and additional security without intermediate handling for small lots of up to 20 cwt.

Three kinds of container were used in the initial stages and from the experience gained the larger one illustrated herewith was considered most suitable for general use. The internal dimensions of this container are length, 5ft 5½in; width, 3ft 1in; height, 4ft 3½in.

This container, the tare of which is 5 cwt 2 qrs. 14 lb, is of 70 cubic feet capacity and can carry 1 ton. The top is lidded and one half, being hinged, can be locked; quick release catches are also fitted at each end of this hinged portion. One side of the container, which is made up of plywood panels reinforced on all edges with sheet iron, is detachable.

The two back wheels are fixed, but the front pair are linked to a handle and can be swivelled in any direction. All wheels are solid rubber tyred and the containers are stated to be very easy to manœuvre whether loaded or empty.

Each container is fitted with four retractable legs or stilts, and through a system of levers all four legs are operated simultaneously by a single hand control. When in position the legs raise the container approximately ¼in from the floor. The iron "shoes" forming the base of each leg are serrated on the underside to afford a firm grip, thereby obviating movement during transit.

Experimental 1-ton rail container

The containers are fitted with shackles for lifting purposes and they can also be handled by fork lift truck, if necessary.

Aluminium Hatch Board

A lightweight, yet tough, aluminium hatch board, approved by Lloyd's and the Ministry of Transport, is one of the latest innovations in deck equipment made possible by the introduction of all-welded aluminium construction. An alloy having high resistance to corrosive attack in marine conditions, was chosen for the hatch boards which, it is expected, will prove to be more economical than the traditional timber boards.

The S.S. "Kentwood," a collier, was fitted with six aluminium hatch boards in July, 1954, since which time she has encountered heavy weather and has handled twenty-two cargoes, and recent inspection showed the aluminium covers to be in excellent condition. Measuring 6ft long, 18in wide and 3in deep, and weighing 47¼ lb, each hatch board is fabricated from two sheets of NS.5 alloy supplied by the Northern Aluminium Company, Ltd., formed to a basically rectangular cross section, but with additional rigidity provided by a full-depth longitudinal trough formed on the underside. The bottom of the trough is secured by argon-arc plug welds to the underside of the top sheet, and the ends of the board are closed by means of rectangular pieces of sheet, welded into position. Longitudinal welded seams join the sheets forming the bulk of the shell, and a recessed grip for handling is welded into the top at each end. This form of construction makes the finished hatch board a closed and water-tight vessel with two compartments.

Rigorous tests have shown that the board can withstand all the loads and rough usage likely to be encountered in service despite its lightness, which reduces handling problems to a minimum. In one test, it was called upon to show a deflection of no more than 0·03in under an evenly distributed load of 8 cwt per square foot while simply supported at each end. It was later found that the board was able to withstand a maximum sustained load, after permanent set had occurred, of 16 cwt per square foot. Dropping the board on to concrete from a height of 10ft caused no damage, and as a final test to ascertain its resistance to rough treatment, steel weights of various shapes, weighing up to 40 lb, were dropped on it from heights up to 10ft. After this treatment it still withstood the test load of 8 cwt per square foot.

The board, manufactured by the London Aluminium Company, Ltd., to the designs of the Northern Aluminium Company, Ltd., and marketed by the Aluminium Marine Development Company, is fabricated by argon-arc welding.

Test of Corrugated Steel Pipe Culvert at Cullman, Alabama

BY OUR AMERICAN EDITOR

The use of corrugated steel pipe culverts under high earth fills exceeding 100ft is now being considered as an alternative to the construction of highway and railway bridges in the United States. The " Multi-Plate " steel pipe made by the Armco Steel Corporation is now one of the most commonly used American culvert materials, and the test described was conducted by the research laboratories of the firm on an 84in diameter " Multi-Plate " culvert situated under 137ft of fill near Cullham, Alabama. The results of the test indicate that such pipe can readily be used under high fills provided that the structure is properly back-filled.

IN the course of recent construction work on highway U.S.31, the Alabama State Highway Department was faced with taking the road across the Hurricane Creek near Cullman, Alabama. The 137ft depth of the gorge at the site and the magnitude of the river flow might normally have called for the construction of a highway bridge across the gorge, but for reasons of structural steel shortages and high labour costs it was decided to build an embankment with 7ft diameter by 512ft long " Multi-Plate " corrugated steel pipe culverts spaced at 20ft centres across the embankment to carry the river flows. Because of the very considerable height of fill of 137ft above these culverts, the research laboratories of the Armco Steel Corporation decided to conduct tests on the structure to determine the thrust in three of the pipes with increase in height of earth fill.

The accompanying drawing (Fig. 1) shows a cross section of the embankment and the points at which measurements were taken. The test programme included a determination of the circumferential thrust in the plates using " SR–4 " strain gauges mounted on the neutral axes and a DeShazer strain gauge for checking. The strut forces were determined using two wire strain gauge indicating dynamometers and changes in the radial dimensions of the pipe were also noted. All these determinations were made at various stages of the fill height. It was decided that strain gauges should be installed in six rings of the pipe near the centre of each ring. Four gauges were used in each ring : top, bottom and two sides. The gauges were accurately placed on the neutral axis. For the three rings under the heaviest portion of the fill, strain gauges were mounted in the ring nearest the centre line of the roadway and the next adjacent ring on either side. Strain gauges were also installed at the quarter, half and three-quarter points of the pipe under the upstream slope of the fill. In order to dry the pipe and give maximum efficiency to the operation of the strain gauges a cofferdam was built above the upstream end of the test pipe. Since relatively dry conditions were expected it was decided to waterproof only those gauges situated on the centre ring and on the ring at the quarter point.

Construction Procedure

In constructing the embankments the first task was the diversion of the stream to make way for laying the first line of pipe. After this was accomplished the pipelines were laid on a 2ft uniform thickness of creek-bed sand for bedding. The pipe was installed with a maximum of 6in of camber at the centre of the pipe, to allow for a greater invert settlement under the higher fill at the centre of the pipes. The compaction required under and between the pipes was 100 per cent according to the American A.A.S.H.O. Standard. The size of the rock within 2ft under and 3ft over the pipe was limited to 4in. All this selected fill material was tamped with power-operated hand tampers. Prior to placing the bedding material under the sides of the pipes, the pipes were sprayed with a coating of Koppers Bitumastic No. 50, an asphalt base preservative. The bolts were tightened with pneumatic impact spanners and checked with a torque spanner to a minimum of 150 ft-lb. The pipes were field strutted to make the pipe 3 per cent out-of-round, vertically.

The fill was placed in lifts of 3ft maximum, and for the first 10ft depth of cover rock was kept away from the area directly over the pipes to avoid disturbing the banks when the imperfect trench was excavated. In the imperfect ditch condition the conduit is first installed as a positive projecting conduit. Then a fill is constructed over it up to an elevation which is one to one and a half times the width of the conduit above its top. In this case the fill was constructed 10ft above the pipe. This fill is well compacted during construction, then a trench is dug in the compacted fill directly over the centre line of the conduit down to the top of the conduit. In this case it was dug to a depth of 7ft, bringing it to within 3ft of the top of the pipe. The width of the trench was the same as the width of the pipe. The trench was refilled with loose back-fill material to the original level and the embankment continued in the conventional manner. The purpose of this method of construction is to allow the interior prism of fill material to settle downward relative to the exterior prisms and to obtain settlement which will generate shearing forces directed upward. Therefore, the load that the pipe must support will be reduced.

The fill material was mainly a crumbly sandstone and rock for the first 25ft. In order to secure the desired density of fill and guard against future settlement, choking was accomplished by alternately placing embankment layers of rock and earth except in the first 10ft immediately over the pipes. The fill material was obtained from borrow pits on both sides of the fill. The borrow pit on the north side consisted mainly of rock, while the borrow pit on the south side, from which the major part of the fill was constructed, was a very crumbly friable sandstone which, after blasting, was easily handled. The fill was largely built using self-loading scrapers. The compaction of the embankment was handled by a combination of dual tandem sheeps-foot rollers. Upon completion of the fill the slopes were dressed, the apron beddings cleared, and the struts pulled from the structure.

Test Procedure

Test readings were made when the earth fill had reached approximate heights of 3ft, 10ft

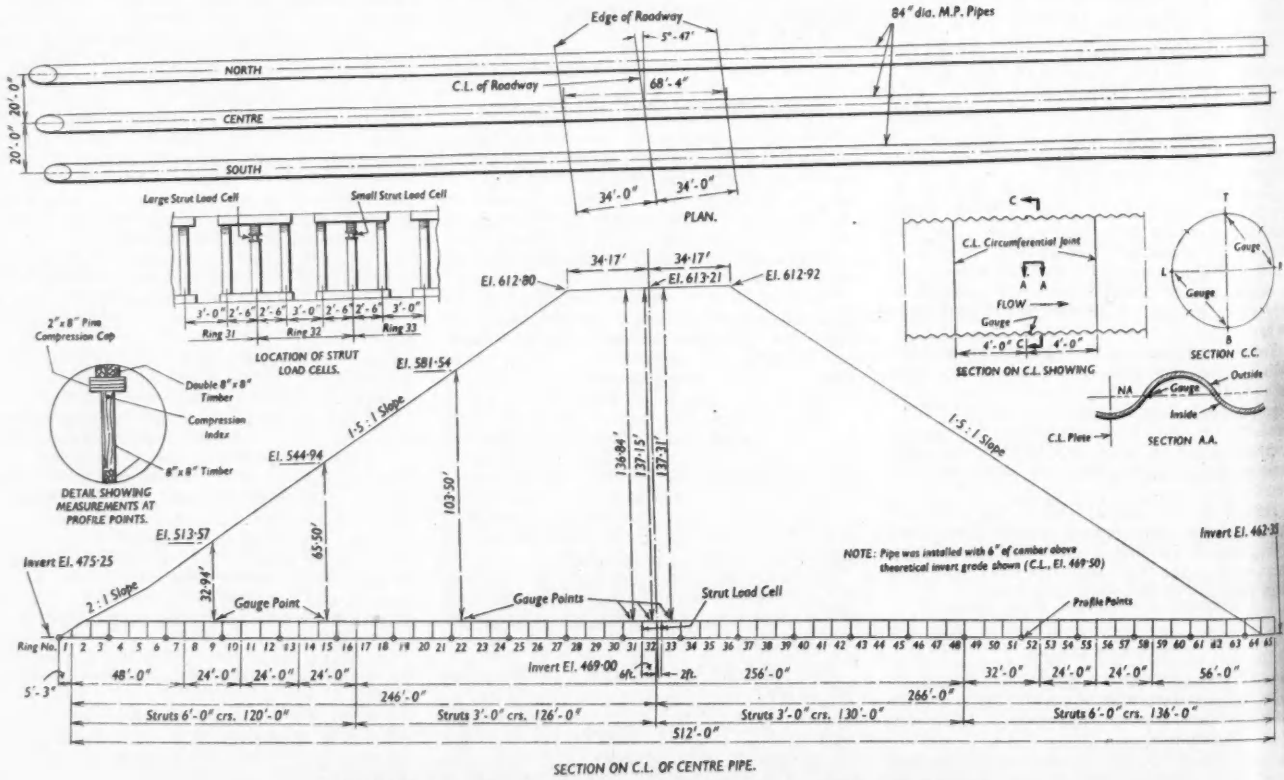


Fig. 1—Cross section of embankment and details of strain recording arrangement

Fig. 2—Original installation of strut load cell without compression caps

(before [and after trenching), 25ft, 45ft, 60ft, 100ft and 137ft. The initial set of test readings was made at a time when the three pipes had been assembled and the 3ft of tamped fill had progressed to a point 384ft from the upstream end. Initial deflection measurements beyond this point were not made until the 10ft level was reached. In the next few days check readings were made on the strain gauge installations. During this time only a few feet of fill were added on the upstream end. All of the side and top gauges provided check readings as did two of the bottom gauges at the centre plates, although all of the bottom gauges were submerged in water.

Since the pipe was installed using the so-called imperfect trenching method it was necessary to obtain a complete set of readings before trenching and again after the trench had been back-filled. The next set of readings was made when the fill height had reached approximately 25ft. At this time it was decided to change the strut load cells, inserting pine compression caps between the oak sills and the cells so that the strut with the inserted load cell would have characteristics similar to those of the adjacent struts (Figs. 2 and 3). This arrangement would allow the load to be distributed more uniformly. Due to rainfall, at this stage of construction the bottom strain gauge installations had been subjected to continuous submersion. It appeared, however, that only five or six gauges were giving inaccurate readings.

The next set of readings was made a fortnight later, by which time the fill had risen to a height of 45ft. Another heavy rain caused the pipe bottom to be filled with rock and silt, and the downstream slope had slipped causing the downstream end of the south pipe to be blocked to a height of 5ft to 6ft. At this time the photograph reproduced in Fig. 4 was taken, showing typical deflection in the compression cap.

Fig. 3—Reinstallation of strut load cell, using Pine compression caps

On completion of the 137ft high earth fill, test readings were made before and after the struts were pulled. The struts were removed by looping a ¾in wire rope around a number of struts and pulling the rope with a "D-8" caterpillar tractor. The number of struts that could be looped at one and the same time was limited by the cable length. The struts adjacent to strain gauge positions were chopped out with an axe and the gauge positions were protected by oak struts so that on the subsequent pulling of the struts by cable the strain gauge installations were not injured. After the struts were removed it was found that the pipes were in good alignment.

Test Results

The test results indicated a maximum vertical deflection of 1·84in or about 2·0 per cent of the original diameter. Since the original diameter was not measured before strutting, the average diameter was computed at 3ft fill height, and this value was taken as the original diameter. The original percentage of vertical elongation and the final percentage reveal that in no case did the pipe reach its original vertical diameter. To the degree of accuracy of the deflection measurements, the pipe remained from ½ to 2½ per cent vertically elongated.

The deflection, in general, followed the pattern that would be expected from the fill profile with the exception that at plate 15, a point about 80ft from the inlet end, the pipe deflection was

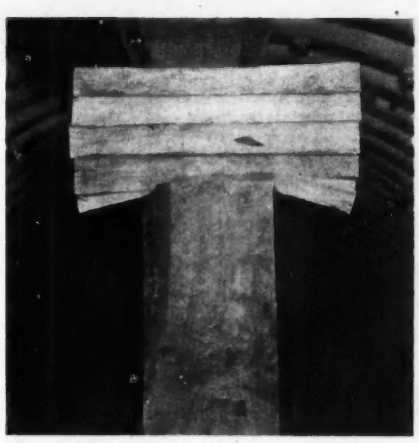


Fig. 4—Compression cap, showing 9/16in deflection under 45ft of earth fill

slightly higher than the deflection under the full height of the fill. While the reason for this cannot be conclusively established, certain factors that possibly could have contributed to this result can be identified. First, the strut spacing at this point changed from a 6ft spacing to a 3ft spacing and the plate thickness changed from No. 3 gauge to No. 1 gauge material. Secondly, this area of the pipe was continually under the ramp of the haul road until about 80ft of fill had been placed. This, of course, meant that the fill and the pipe under this ramp were being continually subjected to the live load of heavy construction equipment. Thirdly, since the struts and sills were only approximately of the same length, a shorter strut could have resulted in a greater deflection and thus a higher apparent load at this position.

The strut load was obtained approximately by measurement of the crushing of the compression caps and use of a load-deflection calibration curve for a similar compression cap. The strut loads were also measured using two strut load cells similar to the unit shown in Fig. 3. The variation of strut load with fill height was plotted and the resulting curve showed that very little "bridging" occurs up to 80ft or 100ft of fill. There is, however, an evidence of bridging above 100ft. The plate stresses as measured by the strain gauges are shown in Fig. 5. These results were taken from the readings of the gauges on the north and south side only. This practice was followed because the bottom gauges which were subjected to water and debris continually after installation, gave inaccurate readings shortly after installation. While the top gauges were operative throughout the tests, some rather high strains were noted, particularly at the higher fills. It is believed that this was due to the fact that local bending of the plate occurred over the top sill, causing the plate arc to act as an individual beam. If the strain gauges were not exactly on the neutral axes or if the section had a slight change of shape, causing a shift of the neutral axes, these strains might be accounted for.

Comparing the strut load with the load carried by the plate on the basis of 1ft seam length, at low fill heights (low loads) the struts carried an appreciable amount of the total load, while at higher fill heights (higher loads) the struts carried a decreasing portion of the total load. This assumes that the total load is the sum of the loads carried by the struts and the plates. It is apparent that the stress at plate 15 is considerably greater than would be expected for its position under the fill. This higher stress is, however, consistent with the greater vertical deflection at this position.

While the loads as measured by the strain gauges are an indication of the true load on the structure they do not necessarily reveal the true thrust load at the seam or the shear tension load on the bolts because of the indeterminate and superimposed load due to strutting. Since the design criterion for this structure is the bolt load, this is of particular significance. The true stress condition of the structure is not revealed in the test results for the following reasons. The pipe after erection was immediately elongated approximately 3 per cent vertically by strutting. This caused the seam to be put in tension at an unknown stress. It was at this point that the strain gauge installation was made and the base readings taken. The thrust load as induced by increased fill height was measured, and while this load could be measured with reasonable accuracy, the final stress condition of the seam could not be measured due to the fact that the original stress was unknown.

Conclusions

The test indicated that the vertical load on the pipe, as shown by the strain readings, agrees substantially with the weight of the vertical column of fill immediately above the pipe. This is the weight used by the makers of the steel pipe to design the strength of the longitudinal seams of flexible culverts under high fills. A lack of knowledge of the residual stresses from the strutting operation prevented an extremely precise measurement of the load on the structure.

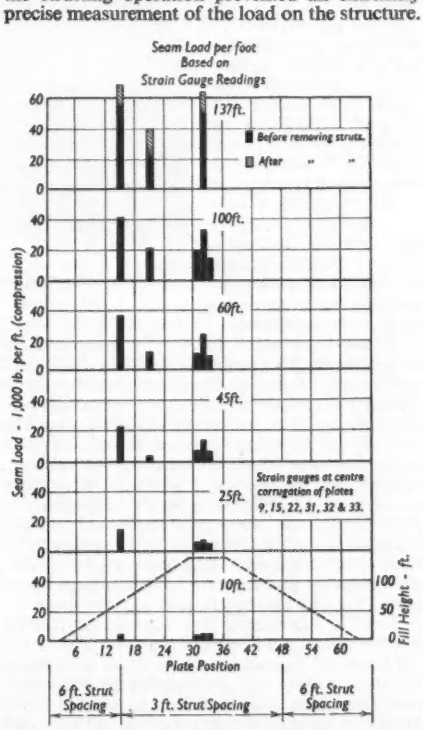


Fig. 5—Strain gauge readings of stresses in culvert plates

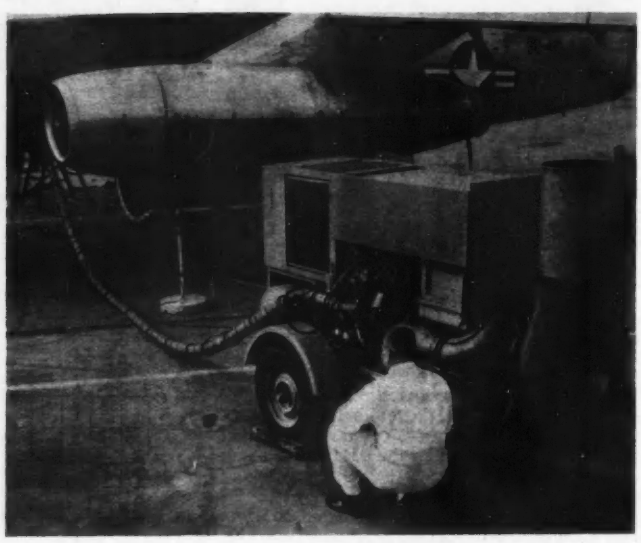
A part of the elongation of the vertical diameter still remained in the structure after completion of the fill and the removal of the struts. This shows that the amount of elongation, the strength of the pipe, the compaction of the backfill and the spacing of the struts were all given proper consideration.

The invert camber of 6in above straight grade as determined by foundation analysis proved adequate as about 3in of this camber remained after completion of the fill.

An analysis of the observed loads on the pipe showed that the methods used to construct a fill can affect the amount of load transmitted to the structure. In the construction of this fill the material was repeatedly brought in over the pipe at one place. Greater loads were measured at this point than the weight of the vertical column immediately above the structure because of this "hard spot" in the fill. In constructing such large fills it would appear desirable to place the material in horizontal layers and compact uniformly so as to transmit the load to the original ground and to the structure in a uniform manner. The readings taken on strut cells and pipe wall strain gauges at successive stages of fill height show that each increment of fill added its increment of load in almost direct proportion.

Ground Power Unit for Starting Jet Aircraft

THE Solar Aircraft Company, of San Diego, California, has been awarded a U.S. Air Force contract for the development of a gas turbine compressor to be used in starting the powerful new jet engines now going into service. It is expected that such a ground power unit will solve a major current aviation problem: finding a portable power source that can supply enough compressed air under all operating conditions for starting such large jet engines as the General Motors Allison "J71" and the Pratt and Whitney "J57." These jet engines require large power inputs to start, particularly when combat conditions require that they be accelerated quickly. Most of the engines are started by supplying compressed air to a small air turbine geared to the turbo-jet rotor, after which the hose delivering the air from the ground power unit is disconnected from the aircraft. The ground power unit may also be used to supply electric and hydraulic power to the aircraft for testing its equipment prior to the main engines being run up.

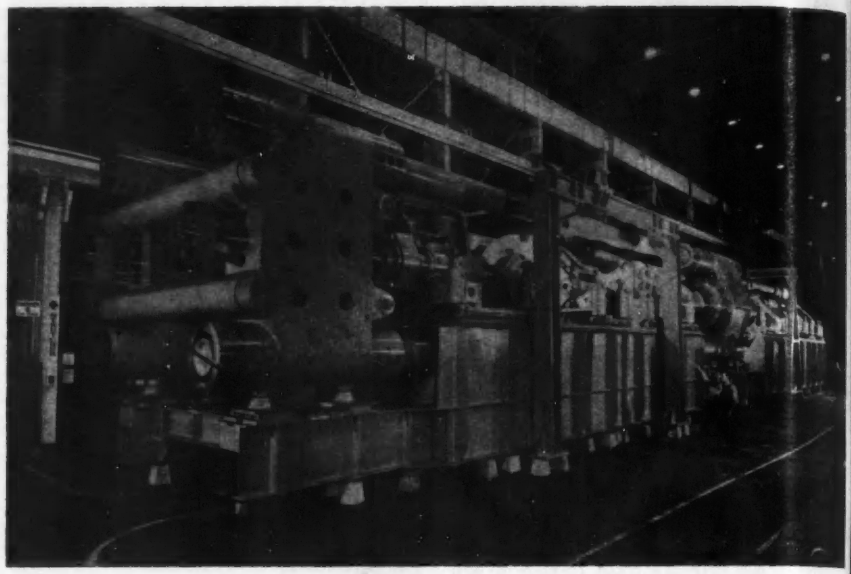


Gas turbine-driven ground power unit starting a Douglas "RB-66" reconnaissance bomber

Under a previous U.S. Air Force contract the company modified one of its 500 h.p. "Jupiter" gas turbine engines so that it will furnish most of its output in the form of compressed air, bled from the gas turbine compressor. The resulting engine has been built into a mobile, portable ground power unit for starting jet aircraft. Known as the model "T-300J," the ground power unit, which is shown in the accompanying illustration, has been used successfully at the Douglas Aircraft Company in Long Beach to start the "RB-66" reconnaissance bomber. It was found that the two "J71" engines of the aircraft could be started quite rapidly using the "T-300J" unit, and that the engine starting temperatures were lowered substantially. The advantages claimed for the ground power unit include its small size and light weight, making it easily movable and portable; its ease of maintenance, its reliable starting in cold or hot weather, and its ability to use the same fuel as the jet engines being started.

8000-Ton Hydraulic Extrusion Press

THE accompanying illustration shows the completed shop erection of an 8000-ton hydraulic extrusion press designed by Loewy-Hydropress, Incorporated, of New York, and built by the Nordberg Manufacturing Company, of Milwaukee, Wisconsin. The machine is one of two 8000-ton presses to be installed at the Halethorpe Works of the Kaiser Aluminum and Chemical Corporation, in Maryland, as part of the U.S. Air Force Heavy Press Programme. A third press of similar design and capacity will be installed at the works of the Harvey Machine Company in Torrance, California. It is expected that the heavy extrusion and forging presses now being completed for the U.S. Air Force will fill a major gap in American facilities to mass-produce airframe components for the latest designs of jet aircraft. Engineers have been looking forward for some time to using larger one-piece extruded and forged shapes that are stronger yet lighter than composite ones. These methods of working with aluminium, titanium, steel and other alloys will provide superior and more economical production techniques than conventional fabricating methods involving riveting, welding and bolting of several smaller pieces.



Shop erection of 8000-ton hydraulic extrusion press

The following specifications apply to the machine illustrated :—

Capacity	8000 tons hydraulic pressure
Length	174ft, including hydraulic equipment, controlling mechanism and run-out tables
Width	18ft 2in
Height	18ft
Weight	4,000,000 lb
Operating pressure	4500 lb per square inch
Hydraulic medium	Water with a small percentage protective oil
Stroke :	
Main cylinders	12ft
Mandrel cylinder	17ft 2in
Maximum cycles per hour	24 cycles
Material to be extruded	Aluminium
Maximum billet size	15in diameter by 60in long weighing approx. 1000 lb
Maximum circular extrusion	17in diameter
Maximum flat extrusion	33in in width
Maximum finished length of extrusion	85ft

In accordance with the present plans of the U.S. Air Force, all ten units in the Heavy Press Programme should be in operation by September. Details of these units are listed in the table below.

The Reynolds Metals Company is no longer on the list of operators. The 8000-ton Loewy and the 12,000-ton Lombard extrusion presses which were to have gone to that company at Phoenix, Arizona, have been reassigned as shown. An eleventh press, which is being built by Bliss, will be stored in an incomplete condition at the Kaiser Works in Newark, Ohio.

Unit	Builder	Operator	Location	Scheduled operating date
50,000-ton forging press	Loewy-Hydropress, Inc.	Wyman-Gordon	North Grafton, Mass.	April, 1955
35,000-ton forging press	Loewy-Hydropress, Inc.	Wyman-Gordon	North Grafton, Mass.	April, 1955
50,000-ton forging press	Mesta Machine Company	Alcoa	Cleveland, Ohio	March, 1955
35,000-ton forging press	United Engineering and Foundry Company	Alcoa	Cleveland, Ohio	March, 1955
8,000-ton extrusion press	Loewy-Hydropress, Inc.	Harvey	Torrance, California	April, 1955
8,000-ton extrusion press	Loewy-Hydropress, Inc.	Kaiser	Halethorpe, Maryland	April, 1955
8,000-ton extrusion press	Loewy-Hydropress, Inc.	Kaiser	Halethorpe, Maryland	September, 1955
12,000-ton extrusion press	Loewy-Hydropress, Inc.	Curtiss-Wright	Buffalo, New York	February, 1955
12,000-ton extrusion press	Lombard Engineering Company	Harvey	Torrance, California	August, 1955
13,200-ton extrusion press	Schloemann Works	Alcoa	Lafayette, Indiana	July, 1954
25,000-ton forging press	E. W. Bliss Company	Uncompleted	Placed in storage at Newark, Ohio	—

Industrial and Labour Notes

Full Employment

At the quarterly meeting of the National Joint Advisory Council, which was held in London on Wednesday of last week, a review of the employment situation was presented by Mr. Harold Watkinson, Parliamentary Secretary to the Ministry of Labour. He said that, except for the fuel crisis in 1947 and the slight recession in 1952, unemployment since the war had averaged round about 300,000, or 1·5 per cent of the working population. The achievement of that low level of unemployment had brought, however, a number of problems of labour supply, for although something like 1,000,000 people had been added to the working population in the last six years, there was still a heavy demand for labour.

Mr. Watkinson went on to say that there should be a balance between the supply of and demand for labour, but inevitably this did not happen in every industry, in every locality and in every occupation. Some industries had not found it as easy to maintain or add to their labour forces as others, and, in the competition for labour, some industries had proved more popular than others to the workers available. In particular, Mr. Watkinson said, coal mining had shown a deficiency in labour supply. Recently the shortage had been mainly in North Staffordshire and South Yorkshire, and, to a lesser degree, in the Aberdare area of South Wales. A publicity campaign launched by the Ministry of Labour had helped to improve the situation, and during this year the Ministry was co-operating with the National Coal Board in an intensive and sustained campaign to stimulate recruitment for coal mining.

Mr. Watkinson also commented upon employment in the development areas. He said that up to the end of last year about 71,000,000 square feet of factory space had been built in those areas, and it was reckoned that that had provided something like 225,000 more jobs. The present rate of unemployment over the development areas as a whole was just under 2·5 per cent. But, Mr. Watkinson remarked, there was still need for further industrial expansion in the development areas. Several of them still remained unduly dependent on one or more of the older basic industries and the need for the Government to steer new industries to the areas was still recognised as of primary importance. Within the general distribution of industry policy, every effort was also being made to attract to the new towns industry which could not go to the development areas or other places of specially heavy unemployment. This involved close co-operation between the new town development corporations and the Government departments concerned. The Ministry of Labour, Mr. Watkinson explained, was responsible for general advice on the manpower aspects, and although it had not always proved easy to attract industry to some of the new towns, there was now, broadly speaking, enough employment available or in prospect to permit an orderly increase in their population.

Trade Disputes

During March, there were 198 stoppages of work through industrial disputes reported to the Ministry of Labour. In addition, there were twenty-nine stoppages, which began before March, still in progress during that month. In these 227 stoppages, 55,800 people were involved during March and 148,000 working days were lost. The Ministry of Labour says that of the stoppages of work through disputes which ended during March, seventy-one, directly involving 5800 workers, lasted not more than one day; fifty-six, directly involving 7600 workers, lasted two days; thirty-seven, involving 23,000 workers, lasted three days; twenty-three, involving 6200 workers, lasted four to six days, and eighteen stoppages, involving 7400 workers, lasted more than six days.

In the first three months of this year, there were 588 stoppages of work through disputes reported to the Ministry of Labour. In them, 140,000 workers were involved, the aggregate number of working days lost being 395,000. In the comparable months of last year, there were 562 stoppages, involving 129,800 workpeople and causing a loss of 435,000 working days.

Industrial Production

The index number of industrial production (1948=100), which is prepared by the central statistical office of the Treasury, has been estimated at 138 for all industries in February, compared with a revised figure of 134 for January. The figures for the corresponding months last year were 130 for February and 127 for January. Taking the manufacturing industries only, the index number for February this year is put at 142, compared with 132 a year earlier; for mining and quarrying it was 116, compared with 118, and for gas and electricity supply, the index number for February was 176, against 166 last year. The Treasury says that, according to information so far received, the index for all industries in March is likely to work out at 139 or 140.

Changes in Wage Rates

In its report on changes in wage rates which took effect in the United Kingdom during March, the Ministry of Labour says that increases aggregating approximately £1,266,000 were made in the weekly full-time wages of about 3,119,000 workpeople. The principal increases affected workers employed in the engineering and shipbuilding industries, in motor vehicle repair and retail establishments, and in the iron and steel industries.

The increases payable in the engineering and allied industries and in shipbuilding, resulted from the wage award announced early in March. They amounted to 11s. a week for skilled adult male workers, 9s. 6d. a week for the intermediate grades, and semi-skilled men and 8s. for unskilled men. Women in the engineering industry received an increase of 7s. 4d. a week. In the motor vehicle repair and retail trade there were wage increases for men amounting to 3d. an hour for skilled operatives, 2½d. for semi-skilled workers, 2¼d. for unskilled men, and of 2d. an hour for women. In the iron and steel industry there were small increases payable under sliding-scale arrangements based on the index of retail prices.

The Ministry says that in the first three months of this year, changes in wage rates resulted in an aggregate increase of £2,432,900 a week for 7,638,000 workpeople. In the comparable period of last year, increases aggregating £826,000 were made to the weekly wages of 3,415,000 workpeople. The changes in wage rates which took effect in March resulted in the index of rates of wages (June 30, 1947=100) moving up three points to 149 for all workers. At the end of March last year, the index, for all workers, stood at 139.

Earnings of Industry

A booklet entitled *The Earnings of Industry* has been published by Aims of Industry, Ltd. Its purpose is to demonstrate the true relation between the profits earned by producers, and wages, salaries and cost of materials. The booklet emphasises that the word "profit" in trading accounts can be very confusing and can give rise to much misunderstanding. The greater part of what is called profit in a balance sheet is not, and cannot be, available for the stockholders and shareholders, and, it is urged, the community should be made fully aware of the fact. The booklet says that if the tables it contains are examined it will be found that, in general, "the final figure of distributable dividend is fair to the lender of the money, fair to the community and, above all, fair to the wage and salaried earners."

Railway Wages

Last Saturday afternoon it was announced that the Associated Society of Locomotive Engineers and Firemen had directed its members employed on British Railways to continue work, and not to begin the strike timed for midnight on Sunday. This decision followed a meeting on Saturday morning between the executive of A.S.L.E.F. and representatives of the British Transport Commission, a meeting which was arranged on the advice of the general council of the Trades Union Congress.

The strike was threatened on account of dissatisfaction over a pay award made by the Railway Staff National Tribunal in respect of footplate men and locomotive shed employees of British Railways. The union contended that the award did not provide a satisfactory differential between the wages of skilled locomotive men and those of other grades. On Thursday of last week, officials of the Ministry of Labour had talks with representatives of the British Transport Commission and the Associated Society of Locomotive Engineers and Firemen, but a formula then agreeable to the Commission as a basis for further discussion of the matter in dispute was rejected by the union executive.

When, however, representatives of both sides met together on Saturday morning, a slightly modified version of this formula was accepted. It was agreed that the Railway Staff National Tribunal's award should be accepted, but that there should take place immediately talks between the British Transport Commission and A.S.L.E.F. on the question of the differential. A meeting to that end was held last Monday.

Railway Charges

At the end of last week, the British Transport Commission announced that, in consequence of the large increases in wage and salaries and of certain other increased costs, it had become necessary to increase passenger and freight charges. It was emphasised that these proposed increases resulted from the cumulative effect of the greater costs already being borne by the Commission.

The details of the increases show that third-class passenger fares on British Railways are to go up from 1·75d. to 1·88d. a mile, and first-class fares from 2·62d. to 2·82d. a mile. There are corresponding increases in London Transport rail and road fares, and in season ticket rates and early morning fares. The general increase on freight and parcels charges is 7½ per cent, though an increase of 15 per cent is to be made in charges for freight traffic in consignments of less than 1 ton by goods train, and for traffic by passenger train, other than perishables and traffic carried at the loaded van scale. The increase for canal and dock charges is to be 7½ per cent. All the increases become effective on June 5th.

It is stated that the total yield from these increases is estimated at £25,000,000 in a full year, but that this anticipated yield will not bridge, by a wide margin, the gap caused by increases in wages and salaries which are already in operation. The Commission has said that it is not, in fact, passing on to the public the full weight of these increased staff costs. Its intention is that the industry itself shall make the substantial contributions necessary to close the gap, partly by continuing to increase its efficiency, and partly by improvements to be expected from other developments, such as the greater freedom to attract remunerative business under the freight charges scheme recently submitted to the Transport Tribunal, and also by the effects of the railway modernisation plan. But, the Commission has explained, the proposals which it has now made are one of the inescapable measures required in fulfilment of its duty to meet, as far as possible, increases in costs already borne, and thus minimise its deficit. The Commission's official accounts for 1954 have not yet been submitted to the Minister of Transport, but the deficit on the year's working is expected to be round about £15,000,000.

Personal and Business

Appointments

MR. K. J. HUME has been appointed chief education officer of Dowty Group, Ltd., Cheltenham.

DR. A. L. CULLEN has become reader in electrical engineering at University College, London.

MR. A. E. P. TURNER has been appointed secretary and a director of Thompson Brothers (Bilston), Ltd.

WICKMAN, Ltd., Tile Hill, Coventry states that Mr. R. J. Dixon, chief engineer, has been appointed a director.

MR. L. EDGAR has been appointed group publicity manager of John Thompson, Ltd., Ettingshall Wolverhampton.

MR. A. M. WORSWICK, A.M.I.Mech.E., has been appointed chief engineer of Towler Brothers (Patents), Ltd., Rodley, Leeds.

THE PLESSEY COMPANY, Ltd. states that Mr. C. D. H. Webb, executive director, has been appointed director of Plessey International, Ltd.

THE ENGLISH ELECTRIC COMPANY, Ltd., announces the appointment of Mr. H. H. Begent, M.I.E.E., as deputy sales manager of the transformer department at Stafford.

THE NATIONAL COAL BOARD states thqt Mr. W. J. Burton has been appointed assistant to the deputy director-general of the marketing (sales) department at headquarters.

MR. T. A. CROWE, chief managing director of North British Locomotive Company, Ltd., has been elected president of the Locomotive Manufacturers' Association of Great Britain.

THE BRIGHTSIDE FOUNDRY AND ENGINEERING COMPANY, Ltd., announces the appointment of Mr. E. J. Edwards as manager of its London Office at Craven House, 16, Northumberland Avenue, W.C.2.

MR. J. S. BEVAN, assistant managing director of the Union-Castle Mail Steamship Company, Ltd., has been appointed deputy managing director. Lord Maclay and Mr. R. M. Turnbull have been appointed directors of the company.

THE SOUTH EASTERN ELECTRICITY BOARD states that Mr. E. H. Skinner, M.I.E.E., has been appointed chief commercial officer in succession to Mr. C. F. Wells, who has retired. Mr. Skinner was formerly deputy engineer-in-chief to the board.

PROFESSOR L. J. KASTNER, M.I.Mech.E., has been appointed to the chair of mechanical engineering at King's College, University of London, as from October 1st next. At present, he is head of the engineering department at the University College of Swansea.

THE BRITISH THOMSON-HOUSTON COMPANY, Ltd., states that Mr. H. E. Wethered has been appointed executive director of the B.T.H. Export Company, Ltd., in succession to Mr. J. N. MacDonald, who has retired. Mr. Wethered has been manager, eastern sales, since May, 1949.

THE SECRETARY OF STATE FOR SCOTLAND has appointed Mr. George Baxter, M.I.C.E., city water engineer, Edinburgh, to be a member of the fisheries committee of the North of Scotland Hydro-Electric Board and the South of Scotland Electricity Board. He succeeds Mr. William Gray, formerly water engineer of Ayr County Council, who has resigned for health reasons.

METROPOLITAN-VICKERS ELECTRICAL COMPANY, Ltd., announces the following appointments in the X-ray department, which took over the business of Newton Victor, Ltd., at the beginning of the year :— Mr. H. B. Gough, sales manager, and Mr. G. E. H. Deadman (Birmingham), Mr. R. B. Gough (London), Mr. A. R. Holdsworth (Sheffield), Mr. D. Moodie (Glasgow), Mr. H. A. Ryder (Cardiff), and Mr. J. Taylor (Manchester), superintendents of Newton Victor sales.

Business Announcements

ENFIELD INDUSTRIAL ENGINES COMPANY will in future be known as Enfield Industrial Engines, Ltd.

SOCONY-VACUUM OIL COMPANY INC., New York, has changed its name to Socony Mobil Oil Company Inc.

WAYMOUTH GAUGES AND INSTRUMENTS, Ltd., has opened an extension to its works at Godalming, Surrey.

BURTON, GRIFFITHS AND CO., Ltd., has moved its Nottingham office to 18, Carrington Street, Nottingham (telephone, Nottingham 53201).

MONKS AND CRANE, Ltd., has opened a new branch office at 23, Dean Street, Newcastle upon Tyne. Mr. John Coe has charge of stock control and office organisation and Mr. A. Keighley is the area representative.

MARTIN, BLACK AND CO. (WIRE ROPES), Ltd., announces the formation of a Canadian company to deal with the sales of its products in that country. The company is entitled Martin, Black Wire Ropes (Canada), Ltd., and its offices and warehouse are at 2082–84, Albert Street, Montreal. Mr. Gordon McKibbin is president of the new company and Mr. Donald Mann is the secretary.

Miscellanea

ALUMINIUM IMPORTS.—The Board of Trade announces that from to-day, separate licences will no longer be needed for the import from any source of unwrought aluminium, unwrought aluminium alloys and aluminium scrap.

SIDE-OPERATING FORK LIFT CARRIER.—In our issue of April 15th, page 530, we described the Irion side-operating fork lift carrier. The sole agents for this equipment in the United Kingdom and British Commonwealth are Materials Handling Equipment (Great Britain), Ltd., 7, Chesterfield Gardens, Curzon Street, London, W.1.

OBITUARY.—We have learned with regret of the death of Mr. William Brown Pickering, which occurred at Sheffield on April 25th. Mr. Pickering, who was eighty-seven, had been associated with Hadfields Ltd. for no less than fifty-four years. He was a director and commercial manager of the company for thirty-one years, and was a past-president of the Sheffield Chamber of Commerce. We also regret to record the death, on April 6th, of Mr. John Maurice Towler, of Leeds. Mr. Towler, who was fifty-two, was joint managing director of Towler Brothers (Patents), Ltd.

INSTITUTION OF LOCOMOTIVE ENGINEERS.—The summer meeting of the Institution of Locomotive Engineers will be held in Scotland from May 17th to 19th. The meeting will open with a reception and dinner at the Central Hall, Glasgow, on the evening of May 17th. The next day members will visit the Queen's Park and Hyde Park works of the North British Locomotive Company, Ltd., and these visits will be followed by the summer meeting dinner in the evening. On Thursday, May 19th, the members of the institution will visit the Renfrew works of Babcock and Willcox, Ltd., in the morning, and a motor-coach tour has been arranged for the afternoon.

TIPPLER PLOUGH FOR COLLIERY SPOIL HEAPS.—Accumulated spillage left after the tippling of wagons at colliery spoil heaps frequently requires a considerable number of men to remove it and to save this labour a plough to do the job quickly has been invented by Mr. S. Plant, a blacksmith at Hawkins Colliery, Cannock Chase. The plough is attached to a chassis which runs on the railway track, and the blade extends to one side of the track. The blade can be raised and lowered and it extends at an angle of 20 deg. to 40 deg. to the side of the vehicle. Support arms used to raise and lower the blade are operated by rope from a winch mounted on a tripod on the chassis.

APPRENTICESHIP TRAINING.—The Industrial Welfare Society has announced its intention of holding a one-day conference on "Apprenticeship Training" at Robert Hyde House, 48, Bryanston Square, London, W.1, on Tuesday, May 24th. The purpose of the conference, it is stated, is to provide opportunity for a critical review and analysis of the subject. At the morning session, beginning at 9.30 a.m., the speakers are to be Mr. John Marsh, on "The Future of Apprenticeship Training"; Mr. Bruce Stanion, on "The Use of the Filmstrip"; and Mr. R. F. Batchelor, on "Industry and the Present Educational System" At the afternoon session at 2.15 p.m. Mr. R. A. F. Harcourt will speak on "The Technical College and Apprenticeship Training"; and Mr. H. F. Walker, on "The Employer's Responsibility Towards the Apprentice."

PETROLEUM INDUSTRY STATISTICS.—The Petroleum Information Bureau has published a booklet which records the statistics of the United Kingdom petroleum industry for 1954 in tabular form. Table I shows that the total consumption of petroleum products, excluding bunkers for ships engaged in foreign trade, amounted to 21,038,511 tons, compared with 19,002,695 tons in 1953. The total includes 5,922,408 tons of motor spirit, 1,310,917 tons of kerosene, 1,413,207 tons of Derv fuel, and 8,275,297 tons of gas, diesel and fuel oils. A second table details motor spirit deliveries and another table analyses the consumption of gas, diesel and fuel oils by various industries. The overall production of petroleum products is given at 28,077,765 tons, against the 1953 total of 25,395,959 tons, and this total includes 7,124,514 tons of motor spirit, 4,191,809 tons of gas/diesel oil, and 11,369,258 tons of fuel oil.

HISTORY OF ALUMINIUM COMPANY.—We have received a copy of a booklet with the title "The History of the British Aluminium Company, Ltd., 1894–1955." The book opens with some account of the early history of aluminium, beginning with the work of Sir Humphry Davy and ending with developments resulting from the discoveries of Hall, Heroult and Bayer. After touching upon the question of raw materials and manufacture the next three chapters in the book are concerned with the history of the company. The first chapter describes the growth of the company from its registration in 1894 to 1910, during which works were started at Larne and hydro-electric schemes developed at Foyers and Kinlochleven, and the second deals with the years until 1939 and the establishment of works at Warrington and Burntisland and the completion of the Lochaber hydro-electric scheme. The period of the second world war and after forms the subject of the third chapter and records the construction of the rolling mill at Falkirk, while the final sections of the book discuss subsidiary and associated companies at home and overseas; the research laboratories at Chalfont Park; welfare, industrial relations and estate management. A large number of photographs illustrate the various works and interests of the company and there is a chronological table of the development of aluminium production.

JUNIOR INSTITUTION OF ENGINEERS.—The Junior Institution of Engineers held a dinner last Friday to celebrate the seventy-first anniversary of its foundation. Dr. S. B. Hamilton proposed the toast of "The Institution" and in the course of his address issued both grave and humorous warnings concerning the present pace of development in engineering technology. The chairman, Mr. A. S. Ladley, responded. The toast of "Engineering Education and the Future" was proposed by Major-General Valon and Professor S. J. Davies responded. Professor Davies, who is Dean of the Royal Military College of Science at Shrivenham, mentioned the growing need for highly trained technologists in the Mechanised Forces, and spoke of the present training scheme with which he is concerned at the College. The toast of "The Guests" was proposed by Mr. J. C. Y. Baker and Mr. W. K. Wallace responded.

SCHOLARSHIP SCHEME.—Two scholarships are to be awarded annually by The General Electric Company, Ltd., to people of outstanding promise in its home establishments or associated companies. Examples of the work for which these scholarships are intended to provide are degree courses in electrical or mechanical engineering, general or special sciences, post-graduate research, and courses in more specialised subjects like production engineering and glass technology. Studies in management or commerce will also be acceptable. It is stated that no restrictions on a candidate's age or choice of subject are envisaged in the scheme, provided that he has already shown that he possesses the ability and personal qualities which indicate with reasonable certainty that he is destined to take up responsible work in the future, and that there is every prospect of his having a useful and satisfying career in the direction of his choice within the company.

LOCOMOTIVE USED FOR TUNNELLING RECORD.—In our note in the issue of April 22nd last, referring to the equipment used in connection with the tunnelling record at the Allt-na-Lairige project, we failed to mention that the diesel underground locomotive used to haul the experimental shuttle car was supplied by F. C. Hibberd and Co., Ltd.; Coronation Road, London, N.W.10. This locomotive was one of the firm's "Planet" 24in gauge 5-ton locomotives. It was specially designed to provide the hydraulic power required for operating the conveyor floor of the shuttle car, and enable operation of the locomotive from the opposite end of the 70ft long shuttle car to which it was coupled. For this purpose remote controls for the locomotive clutch, forward and reverse gears, brakes, throttle, &c., were provided to enable the driver to control movements from the opposite end of the car and near the loading station as tunnelling progressed.

WASTE PAPER RECOVERY.—The Waste Paper Recovery Association has just published its annual report for 1954. The Association, it may be recalled, is a non-profit organisation operating in collaboration with the Board of Trade. Its report emphasises the continuing importance of waste paper as an essential raw material for the mills producing paper, building board, fibre board containers and other packaging papers. It is stated that the amount of waste paper recovered and consumed last year exceeded 1,000,000 tons, which, it is claimed, saved the country about £25,000,000 in foreign currency. The report says that the diversity of the production of many mills to meet the growing demand for packaged goods, the expanding use of various kinds of building boards and of fibre board cases suggests that waste paper, properly recovered, can continue to provide an ever-increasing proportion of the necessary raw material. It has been estimated, on the basis of last year's figures, that the paper and boardmaking mills will require a further 100,000 tons during 1955.

"SPECTRE" ROCKET MOTOR.—The de Havilland Engine Company, Ltd., is now permitted to announce the existence of a new liquid-propellent rocket motor, the de Havilland "Spectre." This engine has been specifically designed for high-performance interceptor-fighters capable of achieving very high supersonic speeds in rarefied atmospheres. Experience gained with the "Super Sprite" assisted-take-off rocket, the first British liquid-propellent rocket engine to pass a Government type-approval test, has been applied to the new de Havilland "Spectre." The combination of the "Spectre" and the "Gyron" type of engine will provide a mixed-power-plant formula, which, in addition to the more obvious advantages of speed, acceleration, and manœuvrability in the stratosphere, makes possible an ability to perform a very rapid take-off and to maintain an outstanding rate of climb to extreme altitudes. The "Gyron" itself is a turbo-jet engine designed to develop its power at high altitude and high supersonic forward speeds and, hence, functions partly as a ram jet engine under these conditions. Considerable experience has already been gained during extensive test-bed firing. Flight trials with the "Spectre" are scheduled to take place during the summer.

British Patent Specifications

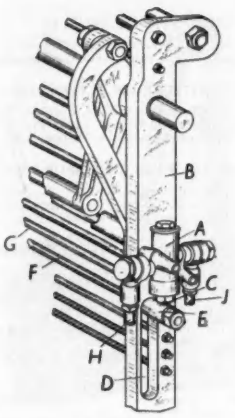
When an invention is communicated from abroad the name and address of the communicator are printed in italics. When an abridgment is not illustrated the specification is without drawings. The date first given is the date of application; the second date, at the end of the abridgment, is the date of publication of the complete specification.

Copies of specifications may be obtained at the Patent Office Sales Branch, 15, Southampton Buildings, Chancery Lane, W.C.2, 2s. 0d. each.

MACHINE TOOLS

726,908. February 20, 1952.—PRESS GUARDS FOR MECHANICAL POWER PRESSES, Industrial Guarding Equipment, Ltd., Mill Works, Alvechurch, Worcestershire. (*Inventors: Albert Edward Bagg and Ivor Maurice Furnivall.*)

In the press guard specified, a control device, such as a pneumatic valve or an electric switch, is provided on the guard frame and is arranged to be operated by an abutment on the slidable screen after the guard



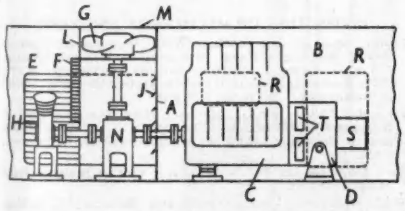
No. 726,908

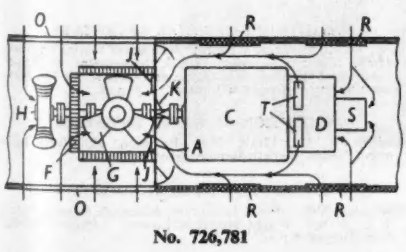
sections have attained a fully fencing position, the control device being adapted to be connected to the clutch-actuating mechanism of the press so as to allow of the clutch engagement only when the guard is closed. In the application, a safety valve *A* is arranged on the outside of one of the slotted uprights *B*. This valve is of the piston type and its depending valve stem *C* is located at the upper limit of the slot *D* and lies in the path of an extended end *E* of the lowermost cross rod *F* of the grill of the slidable section *G*. The valve *A* has an inlet *H* and an outlet *J* respectively to be connected with a source of pneumatic pressure and the valve control. References to two other prior specifications, Nos. 697,284 and 712,054, are made in the specification.—*March* 23, 1955.

RAILWAY ENGINEERING

726,781. February 11, 1952.—RAIL VEHICLES, The English Electric Company, Ltd., Queens House, 28, Kingsway, London, W.C.2. (*Inventors: Walter Gordon Jowett and Leonard Williams.*)

The invention relates to radiator cooling in an engine-electric rail vehicle in which the propulsive power is derived from an internal combustion engine. Referring to the drawing, the engine-room of the





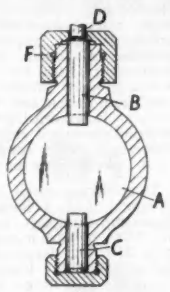
No. 726,781

vehicle is divided by a transverse bulkhead *A* into a rear compartment *B* containing the engine *C* and the generator *D*, and a forward compartment *E* containing an engine radiator *F*, an extractor fan *G*, and a compressor *H*. The radiator is built up from three flat, vertical panels so as to form a three-sided, open-ended box structure, the fourth side of which is closed by the bulkhead. Variable aperture louvres *J* in the bulkhead connect the vertical duct formed by the three panels of the radiator and the bulkhead with the rear compartment *B*, access to the vertical duct being obtained through doors *K* in the bulkhead. The extractor fan *G* is located immediately above the radiator in a housing *L* extending between the top of the radiator and an exhaust vent *M* in the roof and is driven from the engine through shafts and a gearbox *N*. The compressor *H* is driven from the engine, also through the shafts. Cooling air entering the forward compartment *E* through vents *O* in the side walls of the vehicle is drawn through the panels of the radiator by the fan *G* into the vertical duct and exhausted to atmosphere through the vent exhaust. Cooling air entering through filters *R* in the side walls of the rear compartment *B* is drawn by the fan *G* past the engine *C*, through the louvres *J* into the vertical duct, and then exhausted to atmosphere through the exhaust vent. Part of the air entering the rear compartment is drawn directly into the generator *D* and into an overhung auxiliary generator *S* by means of internal fans in these machines and is exhausted into the compartment through the generator vents *T*. The general flow of air in both compartments is indicated by the arrows. Doors are provided in the bulkhead *A* to allow access to either of the compartments. By arranging the radiator within the vehicle and not in the outside walls, a certain amount of protection from frost is obtained. Furthermore, by using a radiator of semi-closed section the length of superstructure required to house a given area of radiating surface in the side walls of the room may be reduced and the construction of the superstructure simplified.—*March* 23, 1955.

VALVES

727,754. November 4, 1952.—A BUTTERFLY VALVE, Power Jets (Research and Development), Ltd., 25, Green Street, London, W.1. (*Inventor: Edward Walter Goody.*)

The invention relates to a butterfly valve, particularly to the sealing of the operating spindle. As will be seen from the drawing, the valve comprises a housing having an internal cylindrical or part spherical bore or cavity connected to the inlet duct of a gas turbine. Within the housing there is a butterfly disc *A* which is mounted upon an operating spindle *B* and a pin *C*, the axis of rotation coinciding with a diameter of the cavity. The operating spindle *B* is supported in a projection of the valve housing wall, and has a shaft *D*, which may be connected to an actuating mechanism or handle. The sealing of the spindle in the valve housing is performed by providing a frusto-conical bearing surface *E* on the spindle and a co-operating surface on a collar *F*, in the form of a nut screwed to the projection. In order to prevent the collar from being screwed too tightly to the projection it has an internal shoulder *G* which abuts the end of the projection, preventing further screwing of the cap and thereby allowing free rotation. This sealing device allows the spindle and disc to rotate freely and provides contact over the whole of the engaging surfaces, thereby affording good sealing and preventing fluid under pressure in the valve from escaping around the spindle.—*April* 6, 1955.

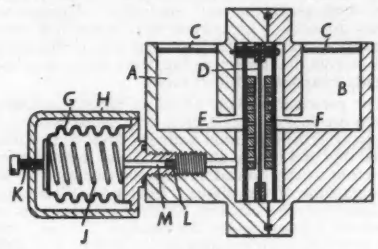


No. 727,754

TESTING INSTRUMENTS AND APPARATUS

727,600. August 22, 1952.—GAS DETECTORS AND ANALYSERS, The Infra Red Development Company, Ltd., 11, Broadwater Road, Welwyn Garden City, Hertfordshire. (*Inventor: William Barrow Bartley.*)

The invention relates to gas detectors and analysers in which the presence and proportion of a gas are ascertained from its specific absorption in the infra-red spectrum. In the drawing the detector chambers are indicated at *A* and *B*. They receive infra-red radiation through the windows *C*. They are separated from each other, except for a capillary leak between them, by a diaphragm *D*, which lies between perforated insulated metal plates *E* and *F*. The diaphragm and one plate form a condenser, the capacitance of which is varied by deflection of the diaphragm. The capillary leak may pass 15 c.c. per minute under a pressure difference equal to 1cm of water. For the purpose of the invention there is attached to one detector chamber *A* a metal bellows *G* protected by a dome *H*, there being a spring *J* to expand the bellows and a screw *K* threaded into the dome *H* and bearing on the end of the bellows for contracting its volume. Communication between the reservoir *G* and the chamber *A* is restricted—for instance, by a plug *L* screwed into the connecting passage *M*, so as not to be more free than is communication between the chambers *A* and *B*; differences of pressure between the detector chambers will not then result from adjustment of the reservoir. The reservoir is filled with the same gas and initially to the same pressure as the detector chambers—that is to say, with the gas to be detected (at a pressure less



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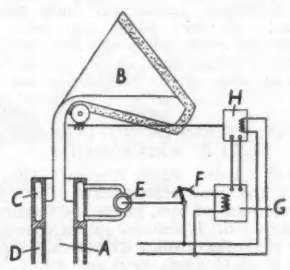
than atmospheric) or with a mixture of the gas to be detected with an inert gas—that is to say, a gas which has no specific absorption for those lines of the spectrum which are strongly absorbed by the gas to be detected. If the calibration curve is found to differ at any point from the original curve of calibration, adjustment of the volume of the reservoir will restore it. The adjustment can be made automatic. After the sample of gas to be tested has been replaced by a standard sample similar to that in use in the other vessel, the motor which normally restores balanced conditions by interposing a screen in the path of part of the infra-red beam may be made to turn the screw *K*, so restoring balance by varying the pressure in the detector chambers.—*April* 6, 1955.

METALLURGY

728,144. June 16, 1952.—CONSTANT CASTING SPEED IN CONTINUOUS CASTING, Allmanna Svenska Elektriska Aktiebolaget, Vasteras, Sweden. (*Inventor: Ludwig Dreyfus.*)

The invention refers to a regulator which regulates the tilting speed of the metal receptacle in direct dependence on the level in the mould. Referring to the drawing, *A* is the mould into which the metal is poured from a receptacle *B*. This receptacle has the shape described in the application Specification No. 728,143 to deliver a substantially constant flow of metal when tilted at constant angular speed. The mould *A* has a cooling jacket divided into two portions *C* and *D*, the upper portion *C* embracing only a comparatively short part of the mould inside



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which the metal level is allowed to vary. The lower portion *D* has a separate cooling jacket, the length of, and supply of, cooling medium to which should be sufficient for solidifying the metal and bringing it to the required temperature for being worked. The supply of cooling medium to the upper portion *C*, on the other hand, should be comparatively small, as it does not serve to solidify the metal, but only to provide an indication of the surface through which heat is conducted from the metal to the cooling medium and thereby of the height of the metal level in the mould. This indication is obtained by measuring the difference between the temperatures of the cooling medium at the entrance and at the outlet of the portion *C* by an indicating instrument *E*, which may comprise two thermometers with means for measuring the difference between the temperatures. The tilting speed can be controlled, for instance, by means of an adjustable resister *F* in the circuit of a Ward Leonard generator *G* feeding a motor *H* which drives the tilting mechanism. The resister *F* can be adjusted directly by the differential thermometer *E* by the intermediary of a torque amplifier, or indirectly. A modified arrangement is also described in the specification.—*April* 13, 1955.

British Standards Institution

All British Standard Specifications can be obtained from the Sales Department of the Institution at 2, Park Street, London, W.1

HIGH-PURITY ZINC, ZINC ALLOYS FOR DIE CASTING AND ZINC ALLOY DIE CASTINGS

No. 1003–4 : 1955. Price 3s. These revised standards were originally issued in 1942, when the development of dependable zinc alloys of good mechanical properties had resulted in a rapid increase in the use of zinc alloy die castings for engineering purposes. These alloys are based on the result of much research, and the chemical compositions chosen were those giving the optimum balance of properties. Since subsequent experience has shown that some allowance should be made for the loss of aluminium and magnesium during casting, their limits have been slightly modified in this revision.

The presence in these alloys of certain impurities which are found in zinc ores, may cause liability to intercrystalline corrosion with resultant dimensional instability and loss of strength. These impurities are therefore strictly limited in the basic zinc used for the manufacture of the alloys. Limits have also been included for other elements which were included in the previous edition under the heading "traces," and the same limits are included for the alloys. B.S. 1005, "Sampling and Analysis of High-Purity Zinc and Zinc Alloys for Die Castings," and B.S. 1225, "Recommended Methods for Polarographic and Spectrographic Analysis of High-Purity Zinc and Zinc Alloys for Die Casting," will be revised to include methods for the determination of these additional elements.

Arrangements have now been made for the use of the B.S.I. Certification Mark in connection with this standard. Manufacturers licensed by the B.S.I. to use this mark are required to ensure that the whole of their production of zinc alloy die castings complies with Part 2 of the standard. Recommendations on the design and production of zinc alloy pressure die castings are being issued in a Code of Practice for zinc alloy die casting for engineering, which is in course of preparation.

GLOSSARY FOR VALVES AND VALVE PARTS (FOR FLUIDS) : PART 1, SCREW-DOWN STOP, CHECK AND GATE VALVES

No. 2591 : 1955. Price 10s. 6d. In the course of the preparation of standards for valves of various kinds and for various purposes, it has become apparent that there is a need for consistency in the terminology used to describe individual valves and their parts. For this reason it has been decided that as new standards for valves are prepared and existing standards revised, their terminology will form the subject of glossaries published as additional parts to B.S. 2591.

This standard defines the forms of, and parts for, the following valves :—Screw-down stop valves : globe, oblique, angle and needle valves ; check valves : horizontal, vertical and angle patterns of swing and lift (disc, piston and ball), screw-down stop and check valves and foot valves ; and gate valves : wedge gate, sluice, double-disc gate and parallel slide valves, both inside and outside screw.

WROUGHT STEELS IN THE FORM OF BARS, BILLETS AND FORGINGS

No. 970 : 1955. Price 12s. 6d.—This revised standard specifies requirements for wrought steels in the form of bars, billets and forgings up to 6in ruling section. It also sets out the chemical compositions of En steels which are normally supplied in the form of plate, sheet, strip and wire ; for such products, however, reference should be made to : B.S. 1408, "Hard-Drawn Steel Wire for Springs" ; B.S. 1429, "Annealed Steel Wire for Oil-Hardened and Tempered Springs" ; B.S. 1449, "Steel Plate, Sheet and Strip" ; B.S. 1554, "Rust, Acid and Heat-Resisting Steel Wire" ; B.S. 2056, "Rust, Acid and Heat-Resisting Steel Wire for Springs." To ensure the alignment of this series of standards, B.S. 1449 will shortly be issued in revised form and B.S. 1408 and B.S. 1429 have been amended.

The first edition of B.S. 970 appeared in 1947. Its successor incorporates the results of research and experience during eight progressive years in the iron and steel industry's history. Also included are the case-hardening steels of the En 350 and En 360 series, which were issued as Emergency Specifications in 1951, but which have since become established as standard steels. Other points which will, it is hoped, enhance the usefulness of the standard are : the coverage of Service requirements so far as they are compatible with those of industry as a whole ; an improved layout and a revised arrangement of the contents. The B.S.I. intends to make available an issue of a German translation of B.S. 970. This innovation will make the standard available in readily understood form to German-speaking engineers throughout the world.

Launches and Trial Trips

FORTHFIELD, oil tanker ; built by Hawthorn Leslie (Shipbuilders), Ltd., for Hunting and Son, Ltd.; length overall 555ft 9in, breadth moulded 69ft 3in, depth moulded 39ft, deadweight 18,000 tons ; thirty-three cargo oil tanks, one main pump room, four cargo oil pumps ; two 550kW geared turbine-driven alternators, one 4200kW diesel-driven alternator ; one set of double-reduction geared, two-casing turbines, 8250 s.h.p., steam supplied at 500 lb per square inch and 800 deg. Fah. by two Foster Wheeler "D" pattern water-tube boilers, two 40 tons of fresh water per day evaporators. Trial, April 13th and 14th.

KERMIA, oil tanker ; built by the Netherlands Dock and Shipbuilding Company for the N.V. Petroleum Maatschappij "La Corona," The Hague ; length overall 170m, length between perpendiculars 161·54m, breadth moulded 21·11m, depth 11·89m, draught 8·99m, deadweight 18,000 tons ; thirty-three cargo oil tanks ; service speed 14½ knots ; one set of Parsons geared turbines, steam supplied by two Babcock and Wilcox boilers. Launch, April 16th.

DISCOVERER, bauxite carrier ; built by the Burntisland Shipbuilding Company, Ltd., for the Pan Ore Steamship Company, Inc.; length overall 448ft, length between perpendiculars 425ft, breadth moulded 60ft, depth moulded 29ft 6in, draught loaded 20ft 6in, deadweight 7950 tons ; speed 12 knots ; two long hopper-pattern holds, wing spaces for water ballast ; two turbine-driven generators ; one set of double-reduction geared turbines by David Rowan and Co., Ltd., 3300 s.h.p. at 112 r.p.m. of propeller, steam supplied at 425 lb per square inch and 725 deg. Fah. by two Babcock and Wilcox water-tube boilers. Trial, April 19th.

RED GAUNTLET, trawler ; built by John Lewis and Sons, Ltd., for the Iago Steam Trawler Company ; length between perpendiculars 135ft, breadth 26ft 6in, depth 13ft 3in, electric trawl winch to take 1200 fathoms of 2¼in warp, electric deck machinery, diesel-driven trawler winch generator ; fish-room capacity 9300 cubic feet ; British Polar diesel engine, five cylinders, 800 b.h.p. at 250 r.p.m. Launch, April 21st.

TRIASTER, passenger-cargo liner, built at the Govan Shipyard of Harland and Wolff, Ltd., for the British Phosphate Commissioners ; length between perpendiculars 485ft, breadth moulded 67ft 6in, depth moulded to shelter deck 42ft, deadweight 12,000 tons ; two continuous steel decks, nine watertight bulkheads ; one 25-ton, two 10-ton and ten 5-ton derricks, electric deck machinery ; four 300kW deisel-driven generators ; Harland and Wolff two-cycle, single-acting, opposed-piston oil engine, six cylinders, 750mm diameter by 2000mm combined stroke, 100 r.p.m. Launch, April 21st.

PRESIDENT KRUGER, cargo ship ; built by the Furness Shipbuilding Company, Ltd., for the Northern Steamships, Ltd., Johannesburg ; length overall 467ft 3in, length between perpendiculars 435ft 8in, breadth moulded 59ft, depth moulded to upper deck 39ft 2in, deadweight 11,000 tons on 27ft 9in summer draught ; five cargo holds, fifteen derricks, electric deck machinery, one steam-driven and two diesel-driven 150kW generators ; Hawthorn-Doxford single-acting, two-stroke, opposed-piston oil engine, four cylinders, 670mm diameter by 2320mm combined stroke, 4400 b.h.p. at 115 r.p.m., two thimble-tube boilers. Launch, April 21st.

TYNEMOUTH, cargo ship ; built by Smith's Dock Company, Ltd., at South Bank-on-Tees, for the Burnett Steamship Company, Ltd.; length between perpendiculars 350ft, breadth moulded 51ft, depth moulded to main deck 25ft 3in, deadweight 5500 tons on 21ft draught, service speed 11½ knots ; four main cargo holds, six 5-ton and two 10-ton derricks, steam deck machinery ; triple-expansion engine, cylinder diameters 18½in, 30½in and 52in by 36in stroke, Bauer-Wach exhaust turbine, 1550 total i.h.p. at 90 r.p.m., steam supplied at 220 lb per square inch and 580 deg. Fah. by two single-ended, multitubular boilers. Launch, April 22nd.

ATHELSTANE, oil tanker ; built by Hawthorn Leslie (Shipbuilders), Ltd., for the Athel Line, Ltd.; length overall 459ft, breadth moulded 61ft, depth moulded 31ft, deadweight 10,000 tons ; twenty main cargo tanks and twelve summer tanks, one main pump room, two cargo pumps ; two 100kW diesel-driven generators, one 50kW steam-driven generator, two cylindrical auxiliary boilers ; Hawthorn-Doxford single-acting, two-stroke, opposed piston oil engine, four cylinders, 670mm diameter by 2320mm combined stroke, 4450 b.h.p. at 112 r.p.m. Launch, April 21st.

Forthcoming Engagements

Secretaries of Institutions, Societies, &c., desirous of having notices of meetings inserted in this column, are requested to note that, in order to make sure of their insertion, the necessary information should reach this office not later than a fortnight before the meeting. In all cases the TIME *and* PLACE *at which the meeting is to be held should be clearly stated.*

BRITISH INSTITUTION OF RADIO ENGINEERS

Wed., May 18th.—LONDON SECTION : School of Hygiene and Tropical Medicine, Keppel Street, Gower Street, London, W.C.1, "The Development of the Underwater Television Camera," D. R. Coleman, D. A. Allanson and B. A. Horlock, 6.30 p.m.

ILLUMINATING ENGINEERING SOCIETY

Tues., May 10th.—LONDON CENTRE : Royal Society of Arts, John Adam Street, Adelphi, London, W.C.2, Annual General Meeting, "The Illuminated Chateaux of France," J. J. Chappat, 6 p.m.

INCORPORATED PLANT ENGINEERS

Tues., May 10th.—MANCHESTER BRANCH : Engineers' Club, Albert Square, Manchester, "Notes on the Statutory Requirements of Steam and Pressure Vessels and Machinery," W. H. Mills, 7.15 p.m.

Wed., May 11th.—E. MIDLANDS BRANCH : County Hotel, Nottingham, Ladies Film Evening, 7 p.m.—GLASGOW BRANCH : Scottish Building Centre, 425/427, Sauchiehall Street, Glasgow, "The Human Factor and Productivity," Mrs. T. M. Ritchie, 7 p.m.

Thurs., May 12th.—N.E. BRANCH : Roadway House, Oxford Street, Newcastle upon Tyne, Film, "'NCK.304' Excavator," 7 p.m.

Tues., May 17th.—S. WALES BRANCH : S. Wales Engineering Institute, Park Place, Cardiff, Ten-Minute Talks and Discussions by Branch Members, 7.15 p.m.

Wed., May 18th.—KENT BRANCH : Bull Hotel, Rochester, Discussion Evening, 7 p.m.

Thurs., May 19th.—BLACKBURN BRANCH : Golden Lion Hotel, Blackburn, "Cotton Spinning Machinery," W. A. Hunter, 7.30 p.m.

INSTITUTE OF BRITISH FOUNDRYMEN

Tues., May 10th.—COVENTRY AND DISTRICT SECTION : Room A5, Technical College, Coventry, "Some Aspects of Cupola Operation," W. H. Bamford, 7.30 p.m.

INSTITUTE OF FUEL

To-day, May 6th.—S. WALES SECTION : S. Wales Institute of Engineers, Park Place, Cardiff, Annual General Meeting, 6 p.m.

INSTITUTE OF PETROLEUM

Wed., May 11th.—26, Portland Place, London, W.1, "Evaporation Losses from Petrol Storage Tanks in the U.K.," E. H. Walker, R. M. Eltringham and A. Puttick, 5.30 p.m.

INSTITUTE OF ROAD TRANSPORT ENGINEERS

Thurs., May 12th.—S. WALES GROUP : S. Wales Institute of Engineers, Park Place, Cardiff, "Paint-Synthetic Resin Finishes and Wet-on-Wet Spraying," C. Butler, 7 p.m.

INSTITUTION OF CIVIL ENGINEERS

Tues., May 10th.—RAILWAY MEETING : Great George Street, Westminster, London, S.W.1, "Some Notes on the Half-Through Type Plate Girder," P. S. A. Berridge and F. M. Easton, 5.30 p.m.

Thurs., May 12th.—STRUCTURAL AND BUILDING MEETING : Great George Street, Westminster, London, S.W.1, "Some Steel Structural Frames Designed on Plastic Theory," D. H. Little and A. Augustus Smith, 5.30 p.m.

Tues., May 17th.—ROAD MEETING : Great George Street, Westminster, London, S.W.1, "Working Capacity of Roads," A. J. H. Clayton, 5.30 p.m.

Thurs., May 19th.—WORKS MEETING : Great George Street, Westminster, London, S.W.1, "The Use of Explosives for Demolitions," D. H. Brook and R. Westwater, 5.30 p.m.

Tues., May 24th.—ORDINARY MEETING : Great George Street, Westminster, London, S.W.1, James Forrest Lecture, "Nuclear Power and World Energy Resources," Sir John Cockcroft, 5.30 p.m.

INSTITUTION OF ELECTRICAL ENGINEERS

Wed., May 11th.—RADIO SECTION : Savoy Place, London, W.C.2, Group of Papers on "Transistor and Other Semi-Conductor Devices," including "Junction Transistor Noise in the Frequency Range 7–50 kc/s," W. L. Stephenson ; "Noise in Silicon Microwave Diodes," G. R. Nicoll, 5.30 p.m.

Thurs., May 12th.—EXTRA MEETING : Savoy Place, London, W.C.2, Discussion on "Image Intensification in Radiology," opened by W. J. Oosterkamp and G. M. Ardran, 5.30 p.m.

Mon., May 16th.—LONDON STUDENTS' SECTION : Savoy Place, London, W.C.2, Annual General Meeting, to be followed by a Film Show, 6.30 p.m.

Tues., May 17th.—EDUCATION DISCUSSION CIRCLE : Savoy Place, London, W.C.2, Questions Night, 6 p.m.

Wed., May 18th.—SUPPLY SECTION : Savoy Place, London, W.C.2, "The Supply of Electricity in the London Area," D. B. Irving, 5.30 p.m.

Thurs., May 19th.—ANNUAL GENERAL MEETING : Savoy Place, London, W.C.2, Corporate Members and Associates only, followed at 6.30 p.m. by "Human Relations in Industry," The Rt. Hon. Lord Citrine.

INSTITUTION OF ENGINEERING DESIGNERS

Fri., May 13th.—N.E. BRANCH : Crown Hotel, Clayton Street, Newcastle upon Tyne, Annual General Meeting, 6.15 p.m.; Annual Dinner, 7.30 p.m.

INSTITUTION OF MECHANICAL ENGINEERS

To-day, May 6th.—1, Birdcage Walk, Westminster, London, S.W.1, Benevolent Fund Extraordinary General Meeting, 5 p.m.—GENERAL MEETING, APPLIED MECHANICS GROUP : "The Reversible Bending of Turbine Shafts with Temperature," A. Barker and F. W. Jones, 5.30 p.m.

Fri., May 13th.—GENERAL MEETING, HYDRAULICS GROUP : 1, Birdcage Walk, Westminster, London, S.W.1, "An Investigation of Hydraulic Lock," J. Manhajm and D. C. Sweeney, 6.45 p.m.

Sat., May 14th.—S. WALES BRANCH : Visit to Bridgend Paper Mills, 10.15 a.m.

Wed., May 18th.—LONDON GRADUATES' SECTION : 1, Birdcage Walk, Westminster, London, S.W.1, Annual General Meeting, "Servo Control," P. J. Bhatt, followed by Discussion, 6.30 p.m.

INSTITUTION OF NAVAL ARCHITECTS

Tues., May 10th.—JOINT MEETING : Institute of Marine Engineers, 85/88, Minories, London, E.C.3, Symposium of Papers, "Advanced Machinery Installations Designed for the Maximum Saving in Weight and Space," 5.30 p.m.

INSTITUTION OF WATER ENGINEERS

Wed. to Fri., May 18th to 20th.—Richmond Hill Hotel, Richmond, Surrey, Sixtieth Summer General Meeting.

ROYAL AERONAUTICAL SOCIETY

Thurs., May 19th.—Royal Institution, Albemarle Street, London, W.1, Wilbur Wright Memorial Lecture, "Flight Control," C. S. Draper, 6 p.m.

WOMEN'S ENGINEERING SOCIETY

Thurs., May 12th.—LONDON BRANCH : 35, Grosvenor Place, London, S.W.1, "Heavy Civil Engineering Works," C. K. Haswell, 7 p.m.